

## 4. NATURE AND EXTENT OF CONTAMINATION

This section summarizes the nature and extent of the contamination at each of the sites of concern for the WAG 9 Comprehensive RI/BRA. Information about the process or release that was the source of the contamination is summarized. The data used in the BRA are identified, and the contaminants carried through the BRA are discussed for each site. The dimensions of contaminated media at each site are presented, and these volumes are summarized in Section 5, Table 5-1. Most data were generated during the Track 1 and Track 2 investigations at WAG 9, and the information summarized below can be found in the respective reports. In addition, during the OU 9-04 remedial investigation field season, ANL-W installed a new groundwater monitoring well downgradient of the Main Cooling Tower Blowdown Ditch (ANL-01A) outfall and drilled one corehole through the EBR II Leach Pit (ANL-08) to determine vertical extent of contamination.

Although data are not available to completely determine the exact boundary that separates contaminated from uncontaminated media at some sites, sufficient data are available to perform the BRA. Realistic, yet conservative assumptions are made, and these are detailed in this section. The result of using these assumptions is to overestimate rather than to underestimate the risk, because overestimation is protective of human health and the environment.

### 4.1 Soils and Vadose Zone Sources at Retained Sites

This section presents the analytical results for soil samples collected at sites that have been retained for evaluation in the baseline risk assessment. For consistency, the retained sites are presented in the same order as the contaminant screening (Tables 3-3 through 3-18). A complete summary of the sampling location, screening of data, statistics, and complete data for each retained site can be found in Appendix A under the appropriate section. The results from this evaluation are used to determine the vertical and horizontal extent of contamination to be used in the baseline risk assessment.

#### 4.1.1 OU 9-01: PCB-contaminated Soil Adjacent to ANL-61 (ANL-61A)

This site is basically the east portion of site ANL-61, EBR II Transformer Yard, where PCB-contaminated soil was not removed. The only contaminants identified at this site are PCBs. Based on the nature and extent of contamination at ANL-61 (RUST Geotech 1994), the majority of the contamination is located at depth [i.e., 1.2 to 2.7 m (4 to 9 ft)] and in one corner of the site with aerial dimensions of 4.6 × 6.4 m (15 × 21 ft). The aerial dimensions are bounded on three sides by the EBR-II facility, and it is bounded on the fourth side by the analytical results from the removal action that occurred at ANL-61.

Section ANL-61A of Appendix A shows the sampling location, screening of data, statistics, and complete data dump for this retained site. Six soil samples were collected from this site with PCB concentrations ranging from 4.1 to 55 mg/kg at locations 534 [2.7 m (9 ft)] below ground surface (bgs) and 537 [1.5 m (5 ft)] bgs, respectively. Two of these samples had PCB concentrations greater than the Toxic Substances Control Act (TSCA) limit of 25 mg/kg. The figure in section ANL-61A of Appendix A shows the sample locations and the detected PCB concentrations. As shown in this figure, the two sample locations with the PCB concentrations greater than 25 mg/kg are in the northern part of the site near Building 768 at a depth of 1.5 m (5 ft) bgs.

#### 4.1.2 OU 9-02: EBR II Leach Pit Extents (ANL-08—Extents)

This section along with the following three sections (4.1.3 through 4.1.5) summarize the analytical results for soil samples collected at the EBR II Leach Pit. The data collected for the Leach Pit have been subdivided into four subsections based on the location of the samples collected. These four subsections are extents, sludge, basalt, and interbeds. The extent samples are the samples which were collected of the soil on the north and south sides of the Leach Pit. These samples were used to determine if horizontal movement of contamination from the Leach Pit has occurred. As discussed in Section 3.1.1.2, at one time, the EBR II Leach Pit (hereinafter referred to as the Leach Pit) received all of the liquid wastes (including cooling tower blowdown, laboratory discharges, and sanitary effluents) generated at ANL-W. However, because the Leach Pit could not handle this large volume of liquid industrial wastes, the sanitary wastes and cooling tower water ceased being discharged to the Leach Pit. In 1975, 10 years after sanitary and cooling tower water discharges to the Leach Pit were discontinued, discharges of radioactive wastes to the Leach Pit ceased.

Two soil samples (C1 and C2) were collected of the surficial alluvium/basalt interface located northeast and southwest of the Leach Pit, respectively. These soil samples were analyzed for metals, volatile organic compounds (VOCs), semi-VOCs, PCBs, dioxin/furans, and radionuclides. The samples C1 and C2 were collected to determine the lateral extent of the contamination. Because the Leach Pit was blasted out of basalt to a depth of 10 ft, the lateral samples were collected only 2 ft and 1 ft below grade at the alluvial/basalt interface. These C1 and C2 samples were collected 8 ft and 9 ft above the Leach Pit bottom and will only be used to qualitatively discuss the lateral extent of the contamination. It is highly unlikely that the C1 and C2 samples could have received any contamination that was discharged to the Leach Pit. This is based on the fact that the inlet line was not a pressurized line and was approximately 9 ft below the grade into the Leach Pit, which had four concrete walls and a covered roof. If the Leach Pit backed up, the liquids would have flooded the Meter House before the liquids would overflow the Leach Pit. Thus, the C1 and C2 samples will not be used in the risk assessment. However, the data are presented for memorialization purposes as part of the RI/BRA.

**4.1.2.1 Metals.** In 1991, the two extent samples (C1 and C2) were analyzed for the CLP metals (aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, cyanide, lead, manganese, mercury, nickel, selenium, silver, thallium, vanadium, and zinc). Section ANL-08—Extents of Appendix A shows the sample location map, data screening tables, statistics for COCs by pathway, and combined data set. Based on the results of the contaminant screening, eight metals are retained for evaluation in the baseline risk assessment. These metals are antimony, arsenic, cadmium, cyanide, mercury, sulfate, and thallium.

Antimony was detected at concentrations greater than the upper limit of background (7.4 mg/kg) at both C1 and C2 samples ranging to 12.15 mg/kg in C1 and 8.48 mg/kg at location C2.

Arsenic was detected at concentrations greater than the upper limit of background (7.4 mg/kg) at location C1 at a concentration of 11.93 mg/kg.

Cadmium exceeded upper limit of background (3.7 mg/kg) at both C1 and C2 locations. The maximum cadmium was detected at 4.82 mg/kg at location C1.

Cyanide was detected in the samples collected outside the Leach Pit at 0.96 mg/kg at location C1 and 0.73 mg/kg at location C2. Any detection of cyanide is retained because there is no INEEL background for cyanide.

Mercury was detected in samples collected from locations C1 at a concentration of 0.41 mg/kg and at C2 with a concentration of 0.12 mg/kg.

Sulfate was detected in both samples C1 and C2 with a maximum concentration of 15.8 mg/kg. No INEEL background exist for sulfate so any detect will be retained for further evaluation.

Thallium was detected at concentrations greater than the upper limit of background (0.68 mg/kg) at location C1 with 6.91 mg/kg and 5.00 mg/kg at location C2.

**4.1.2.2 Radionuclides.** Soil samples collected from the extents were analyzed for the alpha-, beta-, and gamma-emitting radionuclides. Of the radionuclides analyzed for in the extents samples (C1 and C2), only Am 241 and Sr-90 were detected at concentration greater than the upper limit of background and Y-90 was retained because it was positively detected and does not have an INEEL background concentration.

Am-241 was detected above the upper limit of background (0.019 pCi/g) at C1 (0.32 pCi/g) and C2 (0.17 pCi/g).

Sr-90 and Y-90 were detected in similar concentrations at all locations. For the purpose of discussing the nature and extent of contamination, only the results for Sr-90 will be presented because they occur in equilibrium. Sr-90 was detected above the upper limit of background (0.76 pCi/g) at location C1 with a concentration of 5.92 pCi/g and was detected at a concentration below the upper limit at C2.

**4.1.2.3 Organic Compounds.** Only one organic contaminant was identified in the C1 or C2 extent samples. This organic contaminant is OCDD and had an estimated concentration of 0.052 mg/kg at location C1.

#### **4.1.3 OU 9-02: EBR II Leach Pit Sludge (ANL-08—Sludge)**

This section summarizes the analytical results for the sludge samples collected at the EBR II Leach Pit. Section ANL-08—Sludge in Appendix A shows the plan map of samples, screening tables, statistics for COC by pathway, and combined data set used in the following sections. In 1991, three of the samples (G1, G2, and G3) were collected from the sludge remaining in the bottom of the Leach Pit. Based on the documentation in the Track 2 Summary Report, it appears samples G1 and G3 were collected within two feet of each other using remote sampling techniques through the access manhole. All of these sludge samples were analyzed for metals, volatile organic compounds (VOCs), semi-VOCs, PCBs, dioxin/furans, and radionuclides. The sludge in the bottom of the Leach Pit was removed during a removal action conducted in 1992. Because the sludge has been removed, the three samples (G1, G2, and G3) were used to model the contaminants to the groundwater. These positive detection's of contaminants in the G1, G2, and G3 samples will be analyzed for in the interbed samples below the Leach Pit to assess if the contaminants have migrated through the basalt.

The soils, basalt, and interbed sampling data have been divided into four sections to determine the nature and extent of the contamination. The grab samples (G1, G2, and G3) from the sludge that has been removed will only be used in the modeling of the contaminants to the groundwater for the risk assessment and is shown in Section ANL-08—Sludge of Appendix A. ANL-W will use the historical records of the volume of wastes sent to the Leach Pit and the results of the radionuclides in the sludge.

**4.1.3.1 Metals.** The 1991 soil samples collected from the sludge were analyzed for the CLP metals (aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, cyanide, lead, manganese, mercury, nickel, selenium, silver, thallium, vanadium, and zinc). Based on the results of the contaminant screening, 15 metals are retained for evaluation in the baseline risk assessment. These metals are antimony, arsenic, beryllium, cadmium, chromium, copper, cyanide, lead, mercury, nickel, silver, sodium, sulfate, thallium, and zinc.

Antimony was detected at concentrations greater than the upper limit of background (7.4 mg/kg) in all three grab samples in the Leach Pit. The maximum sample concentration was 37.09 mg/kg.

Arsenic was detected at concentrations greater than the upper limit of background (7.4 mg/kg) at two of the samples collected from the Leach Pit (G2 and G3) at concentrations of 52.80 and 19.8 mg/kg, respectively.

Beryllium was detected at a concentration greater than the upper limit of background (3.0 mg/kg) at one location in the Leach Pit (G3) at a concentration of 756.09 mg/kg. Beryllium was detected at all other sample locations at concentrations less than background.

Cadmium exceeded the upper limit of background (3.7 mg/kg) in all three grab samples and ranged up to 49.78 mg/kg.

Chromium, copper, and lead were detected at concentrations greater than the upper limit of background (50 mg/kg, 32 mg/kg, and 23 mg/kg, respectively) at all locations in the Leach Pit ranging from 596.25 to 4,305.33 mg/kg, 3,283.56 to 18,839.40 mg/kg, and 93.7 to 287.98 mg/kg, respectively.

Cyanide does not have a background value; thus, any detection is considered to be above background. The cyanide was positively detected in all three grab samples and ranged up to 34.32 mg/kg.

Mercury was detected in two of the samples collected from the Leach Pit at concentrations greater than the upper limit of background (0.074 mg/kg) at concentrations of 496.60 mg/kg at location G2 and 132.90 mg/kg at location G3.

Nickel was detected in one of the samples collected from the Leach Pit at a concentration greater than the upper limit of background (55 mg/kg) at a concentration of 75.24 mg/kg at location G2.

Silver was detected at all locations in the Leach Pit at concentrations ranging from 5.26 to 22.63 mg/kg. There is no established upper limit of background for silver; therefore, all detections are considered to represent contamination.

Only one sample exceeded the upper limit of background for sodium (520 mg/kg) with a concentration of 1047.99 mg/kg.

Sulfate does not have an upper limit of background; thus, the two samples that sulfate was detected in will be retained. The concentration of sulfate ranged from non-detected to 82.2 mg/kg.

Thallium was detected at concentrations greater than the upper limit of background (0.68 mg/kg) at all locations in the Leach Pit ranging from 5.00 to 22.40 mg/kg.

Zinc was detected at concentrations greater than the upper limit of background (220 mg/kg) at all locations in the Leach Pit ranging from 459.75 to 3,016.80 mg/kg.

**4.1.3.2 Radionuclides.** Sludge samples collected from the sludge were analyzed for the alpha-, gamma-, and beta-emitting radionuclides. Of the radionuclides detected, Am-241, Co-60, Cs-134, Cs-137, I-129, Np-237, Pu-238, Pu-239/240, Sr-90, U-234, U-235, U-238, and Y-90 were detected in the sludge samples collected from the Leach Pit. These concentrations and results of the nature and extent of contamination are described below. These contaminants remain in the 1/16-th of an inch of sludge in the bottom of the Leach Pit. The sludge was removed in 1993 and an impermeable layer of clay was placed over the top to inhibit the leaching by rainwater. These known contaminants in the sludge will be used as indicator parameters for the samples collected below the Leach Pit in the subsurface interbeds.

Am-241 was detected above the upper limit of background (0.019 pCi/g) at locations G2 (0.25 pCi/g), G3 (0.65 pCi/g).

Co-60 was detected in all the sludge samples collected from the Leach Pit ranging from 61.3 to 196 pCi/g. There is no established upper limit of background for Co-60; therefore, all detections are considered to represent contamination.

Cs-134 was detected at locations G1 and G2 at concentrations of 0.62 pCi/g and 1.8 pCi/g, respectively.

Cs-137 was detected above the upper limit of background (1.28 pCi/g) in all the sludge samples collected from the Leach Pit ranging in concentration from 6,619 to 29,110 pCi/g.

There are no background concentrations for I-129; therefore, any detection is considered to represent contamination. I-129 was detected in one sample (G3) at a concentration of 124 pCi/g.

Np-237 was detected in all the samples collected from the Leach Pit ranging from 46.5 to 329 pCi/g. There is no established upper limit of background for Np-237; therefore, all detections are considered to represent contamination.

The detections of Pu-238 and Pu-239 were both above the upper limit of their respective background concentrations (i.e., 0.0091 pCi/g and 0.19 pCi/g, respectively).

Sr-90 and Y-90 were detected in similar concentrations at all locations. For the purpose of discussing the nature and extent of contamination, only the results for Sr-90 will be presented because they occur in equilibrium. Sr-90 was detected above the upper limit of background (0.76 pCi/g) in all sludge samples collected from the Leach Pit ranging from 12.1 to 2,247 pCi/g.

U-234 was detected at concentrations greater than the upper limit of background (1.95 pCi/g) at all locations in the Leach Pit sludge ranging from 14.52 to 35.64 pCi/g.

U-235 was detected at all three sludge samples in the Leach Pit at concentrations ranging from 0.50–2.18 pCi/g. There is no INEEL background concentration for U-235; therefore, any detection is considered to represent contamination.

U-238 was detected above the upper limit of background (1.85 pCi/g) in two sludge samples collected from the Leach Pit (G1 and G2) at concentrations of 3.54 pCi/g and 1.96 pCi/g, respectively.

**4.1.3.3 Organic Compounds.** Soil samples collected from the sludge were analyzed for complete Appendix VIII and IX analysis (soils and waters, respectively) for VOCs, semi-VOCs, pesticides, and dioxin/furans. Two VOCs were detected in the sludge samples from the Leach Pit: methylene chloride

and acetone. Methylene chloride was detected in one sample (G2) from the Leach Pit at a concentration of 74 ug/kg. Methylene chloride was also detected in the method blank at a concentration of 2 ug/kg. Because the concentration detected in the sample is more than 10 times the concentration in the blank, it is considered to represent contamination in the Leach Pit. Acetone was detected in two samples (G1 and G2) from the Leach Pit at concentrations of 280 ug/kg and 1,100 ug/kg, respectively.

Nine polyaromatic hydrocarbons (PAHs) were detected in the sample collected from G3 in the Leach Pit. These PAHs are anthracene, benzo(a)anthracene, benzo(k)fluoranthene, butylbenzylphthalate, chrysene, di-n-butyl phthalate, fluoranthene, phenanthrene, and pyrene, and their detected concentrations range from 51 ug/kg for butylbenzylphthalate to 670 ug/kg for pyrene. Di-n-butyl phthalate was also detected in the sample collected from the 11-m (36-ft) interbed at an estimated concentration of 2,000 mg/kg.

Aroclors 1260 and 1254 were detected in all samples collected from the Leach Pit. Aroclor 1254 concentrations ranged from 2,000 to 6,100 ug/kg, and Aroclor 1260 concentrations ranged from 800 to 1,800 ug/kg.

Ten isomers of dioxin/furans were analyzed for in each sludge sample collected from the Leach Pit. These isomers are tetrachlorinated dibenzodioxin (TCDD), pentachlorinated dibenzodioxin (PeCDD), hexachlorinated dibenzodioxin (HxCDD), heptachlorinated dibenzodioxin (HpCDD), octachlorinated dibenzodioxin (OCDD), tetrachlorinated dibenzofuran (TCDF), pentachlorinated dibenzofuran (PeCDF), hexachlorinated dibenzofuran (HxCDF), heptachlorinated dibenzofuran (HpCDF), octachlorinated dibenzofuran (OCDF). While there is no documented process involving dioxin/furans at ANL-W, it is assumed that they were formed during lead smelting at the Hot Fuel Examination Facility (HFEF), which discharged to the Leach Pit.

#### **4.1.4 OU 9-02: EBR II Leach Pit Extents (ANL-08—Basalt)**

This section summarizes the analytical results for basalt verification samples collected after the removal of the sludge in the EBR II Leach Pit. Section ANL-08—Basalt of Appendix A shows the sample plan map, screening tables, statistics, and data set.

In 1993, seven samples were collected from the basalt at the base on the Leach Pit, and the majority of the sludge was removed from the Leach Pit. These basalt samples will not be included in the risk assessment since the contaminants would not be absorbed or adhere to the basalt. Currently, only 0.16 cm (1/16<sup>th</sup> in.) of sludge remains in the bottom of the Leach Pit. The basalt samples that were collected after the sludge was removed will not be used in the risk assessment. Because of the characteristics of the basalt, no contamination would be absorbed on the basalt. Thus, the only data set that will be used to determine the vertical migration of the contaminants is the data set from the four interbed samples. The interbed data are shown in Section ANL-08—Basalt of Appendix A.

**4.1.4.1 Metals.** The basalt samples collected from the basalt in 1993 were only analyzed for beryllium, chromium, and thallium. As expected, the three metals analyzed for in the samples collected from the basalt were all less than their respective detection limits.

**4.1.4.2 Radionuclides.** Basalt samples collected from the basalt were only analyzed for I-129 and Np-237. There was no difference between the concentrations of the radionuclides detected in the method blank and the samples collected from the basalt.

**4.1.4.3 Organic Compounds.** No organic compounds were analyzed for in samples collected from the basalt.

#### **4.1.5 OU 9-02: EBR II Leach Pit Extents (ANL-08—Interbeds)**

This section summarizes the analytical results for interbed samples collected below the EBR II Leach Pit. Section ANL-08—Interbeds of Appendix A shows the plan map of the corehole locations, screening tables statistics for COCs by pathway, and combined data set. The combined data set will be used to validate the modeling of the migration of the contaminants from the Leach Pit.

In 1991, one interbed soil sample (C3) was collected from the 11-m (36-ft) interbed below the Leach Pit. It was analyzed for metals, VOCs, semi-VOCs, PCBs, dioxin/furans, and radionuclides.

In 1996, a corehole was drilled directly through the center of the Leach Pit approximately 10 ft west of the inlet pipe. The corehole's northing coordinate is 702631.814 and easting coordinate is 369909.961 with an elevation at the casing of 5,120.31 ft mean sea level. Interbed samples below the Leach Pit were collected to determine if the contaminants from the sludge have migrated, and to substantiate the contaminants detected in the 1991 C3 sample. Core drilling was completed to a depth of 147 ft below grade. Three interbeds were encountered at depths of 36 to 38 ft, 60 ft and 147 ft (samples ANL-85-96, ANL-88-96, and ANL-89-96, respectively) with enough sample material at the 36 to 38 foot interbed to run the complete suite of samples specified in the Work Plan. The 36 to 38 sample was analyzed for radionuclides, VOCs, semi-VOCs, pesticides, dioxin/furans, and metals. The sample collected at 60 ft was analyzed for radionuclides, dioxin/furans, and metals. While the sample collected at 147 ft, enough interbed material to analyze for radionuclides was retrieved. In addition to the three interbed samples, one equipment blank was submitted and analyzed for VOCs, semi-VOCs, pesticides, dioxin/furans, and metals; one duplicate sample was collected at the 36 to 38 foot depth and submitted for full suite of samples, and one VOC trip blank accompanied the sample cooler.

**4.1.5.1 Metals.** The one 1991 interbed sample (C3) was analyzed for the CLP metals (aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, cyanide, lead, manganese, mercury, nickel, selenium, silver, thallium, vanadium, and zinc). Interbed samples collected from the corehole in 1996 (ANL-85-96, ANL-88-96, and ANL-89-96, from 36 to 38 ft, 60 ft, and 147 ft respectively) were analyzed for antimony, arsenic, beryllium, cadmium, chromium, copper, lead, mercury, nickel, silver, thallium, zinc, cyanide, and sulfate based on the contaminant screening performed in the WAG 9 Final Work Plan for Operable Unit 9-04 Comprehensive RI/FS (Lee et al. 1996). To aid in understanding of where these samples were collected, they will be referred to by sample depth verses sample number.

Based on the results of the contaminant screening, nine metals and cyanide are retained for evaluation in the baseline risk assessment. These metals are antimony, arsenic, cadmium, calcium, copper, cyanide, mercury, silver, sulfate, and thallium.

Antimony was detected at concentrations greater than the upper limit of background (7.4 mg/kg) in the 1991 (C3) sample at the 11-m (36-ft) interbed at a concentration of 14.91 mg/kg. Antimony was not detected in the two samples from the 1996 coring.

Arsenic was detected at one sample greater than the upper limit of background (7.4 mg/kg) at 7.8 mg/kg at the 1996 60-ft interbed sample.

Cadmium was detected in the one 1991 sample (C3) at a concentration of 8.02 mg/kg that was greater than the 3.7 mg/kg upper limit of background.

Copper exceeded the upper limit of background (32 mg/kg) in only one sample collected in 1996 of the 60-ft interbed at a concentration of 37.7 mg/kg.

Mercury was detected in two of the samples collected at concentrations greater than the upper limit of background (0.074 mg/kg) in the 1991 (C3) sample and also in the 1996 11-m (36-ft) interbed sample. The maximum concentration of mercury was 0.52 mg/kg.

Silver was detected in 1991 (C3) sample collected in the 11-m (36-ft) interbed at a concentration of 3.14 mg/kg. There is no established upper limit of background for silver; therefore, all detections are considered to represent contamination.

Sulfate was analyzed in the 1991 (C3) sample and detected at a concentration of 31.3 mg/kg. There is no established upper limit of background for sulfate; therefore, all detections are considered to represent contamination.

Thallium was detected at concentrations greater than the upper limit of background (0.68 mg/kg) in the 1991 (C3) sample collected at 11-m (36-ft) interbed with a concentration of 9.09 mg/kg.

Cyanide was detected at the 1991 (C3) sample at a depth of 11-m (36-ft) with a concentration of 0.88 mg/kg. There is no established upper limit of background for cyanide; therefore, all detections are considered to represent contamination.

Overall, the concentrations of the contaminants decreased in concentration to below background from the Leach Pit to the 1991 (C3) sample collected from the 11-m (36-ft) interbed. These contaminants are further reduced to the concentrations detected in the 1996 36-ft and 60-ft interbed samples. Metals whose concentrations decreased from the sludge concentrations to levels below background in the interbed samples are arsenic, beryllium, chromium, copper, lead, nickel, and zinc. Metals whose concentrations decreased from the sludge samples to the interbed samples but are still greater than the upper limit of background (or where no background concentration is available) are antimony, mercury, silver, thallium, and cyanide.

**4.1.5.2 Radionuclides.** Soil samples collected from the 1991 (C3) sample collected in the 11-m (36-ft) interbed were analyzed for the alpha-, beta-, and gamma-emitting radionuclides. The interbed samples collected in 1996 were analyzed for Am-241, Co-60, Cs-134, Cs-137, I-129, Np-237, Pu-238, Pu-239/240, Sr-90, U-234, U-235, and U-238 based on the contaminant screening performed in the Final WAG 9 Work Plan for Operable Unit 9-04 Comprehensive RI/FS (Lee et al. 1996).

Radionuclides retained as COCs in the combined interbed data set are, Am-241, Co-60, Cs-137, Np-237, Sr-90, Y-90, and U-235. Of these, Co-60, Np-237, and U-235 were retained because there is no background value. The nature and extent of each of these retained radionuclide COCs is discussed below.

Am-241 was detected above the upper limit of background (0.019 pCi/g) at G3 (0.65 pCi/g). This was collected of the 1991 C3 interbed sample collected at the 11-m (36-ft) interbed.

Co-60 was detected in the 1991 sample (C3) from the 11-m (36-ft) interbed at a concentration of 1.93 pCi/g. There is no established upper limit of background for Co-60; therefore, all detections are considered to represent contamination.



Cs-137 was detected above the upper limit of background (1.28 pCi/g) in only the 1991 (C3) sample collected at the 11-m (36-ft) interbed at a concentration of 93.6 pCi/g.

Np-237 was only analyzed for and detected in the 1991 (C3) sample collected from the 11-m (36-ft) interbed at a concentration of 1.53 pCi/g. There is no established upper limit of background for Np-237; therefore, all detections are considered to represent contamination.

Sr-90 and Y-90 were detected in similar concentrations at all locations. For the purpose of discussing the nature and extent of contamination, only the results for Sr-90 will be presented because they occur in equilibrium. Sr-90 was only detected above the upper limit of background (0.76 pCi/g) in one sample from 1996 collected the 11-m (36-ft) interbed at a concentration of (1.43 pCi/g).

U-235 was detected in four interbed samples below the Leach Pit with a maximum concentration of 0.0726 pCi/g. There is no INEEL background concentration for U-235; therefore, any detection is considered to represent contamination.

Overall, the concentrations of the radionuclides decreased in concentration to below background from the Leach Pit sludge samples to the 11-m (36-ft) interbed samples and continued decreasing in the 60- and 147-ft interbeds. Those radionuclides whose concentrations decreased to below background in the interbed are I-129, Pu-238, Pu-239/240, Cs-134, U-234, and U-238. Those radionuclides whose concentrations decreased but are still greater than the upper limit of background are Am-241, Co-60, Cs-137, Np-237, Sr-90, Y-90, and U-235.

**4.1.5.3 Organic Compounds.** The 1991 interbed sample (C3) was analyzed for the full list of Appendix VIII analysis for VOCs, semi-VOCs, pesticides, and dioxin/furans. In 1996, the 36 to 38-ft sample was analyzed for volatiles, semi-volatiles, pesticides, and dioxin/furans. The deeper interbeds at 60 and 147 ft did not contain enough sample material to analyze for these constituents.

In 1991, di-n-butyl phthalate was detected in the sample collected from the 11-m (36-ft) interbed at an estimated concentration of 2,000 ug/kg. In addition, in the same sample, OCDD was detected at a concentration of 0.24 ng/g. While there is no documented process involving dioxin/furans at ANL-W, it is assumed that they were formed during lead smelting at the HFEF, which discharged to the Leach Pit. The 1996 sample did not contain any organic detects for any of the organics in the sampling suite.

**4.1.5.4 Extent of Contamination.** The extent of the contamination in the Leach Pit is limited to the mass balance of the contaminants that were discharged to the Leach Pit minus the contaminants that were removed in the sludge. The interbed samples were collected to determine if the contaminants have migrated downward from the Leach Pit. The sampling results show that for some unknown reason, the 1991 sample (C3) collected at the 11-m (36-ft) interbed, had the greatest number of detects above background for metals, radionuclides, and organics. The 1996 samples collected at 11-m (36-ft) interbed was collected to confirm the results of the 1991 sample. However, the 1996 11-m (36-ft) sample showed only minor metal contaminants, only two radionuclides (Sr-90 and U-235), and no organics. The samples collected in 1996 of the deeper interbeds (60- and 147-ft) below the Leach Pit were collected to determine the vertical extent of the contamination. These deeper samples only showed copper above background for the 60-ft interbed sample. All other concentrations of metals and radionuclides showed decreasing concentrations with depth.

#### 4.1.6 OU 9-04: Industrial Waste Pond (ANL-01—Industrial Waste Pond)

This section summarizes the analytical results for soil samples collected at the Industrial Waste Pond (ANL-01). As discussed in Section 3.1.1.4.1, this pond was used to receive cooling tower wastes associated with the EBR-II and any discharges to the North Ditch (see Section 3.1.1.4.4), and the ditches were used to transport these wastes to the pond. Waste types discharged to the pond include metals (from the cooling tower wastes) and those wastes associated with the North Ditch (e.g., photo developers, fixers, and stabilizers, acids, ethanol, sodium hydroxide, and some radionuclides) and the Main Cooling Tower Blowdown Ditch (ANL-01A). Only Ditches A and C are currently visible, while the majority of Ditch B was backfilled with clean soil to grade [approximately 1.5-m (5-ft)].

There is one main inflow into the Industrial Waste Pond (IWP). Of the three ditches, only Ditch B flowed directly into the IWP. Ditches A, B, and C flow into the Main Cooling Tower Blowdown Ditch before ultimately flowing into the IWP. Therefore, because the IWP and its three ditches are not necessarily in close proximity to each other, analytical results for the IWP and each of its three ditches will be presented separately in this section and Sections 4.1.7 through 4.1.9.

Section ANL-01—Industrial Waste Pond of Appendix A shows the sampling location plan map, scatter plots of the data, screening tables, statistics for COC by pathway, and combined data sets for all samples collected from the Industrial Waste Pond. Soil and sludge samples were collected from the IWP as part of four different investigations occurring from 1986 to 1994. For the purpose of this evaluation, analytical results from both soil and sludge are combined and referred to as soil samples. In the 1986 ANL-W study (ANL-W 1986), four subsurface soil samples were collected from the vicinity of the inlet pipe. In 1987, one composite soil sample was collected from three locations approximately 30 to 60 m (100 to 200 ft) north of the inlet pipe. In 1988, six soil samples were collected throughout the eastern part of the IWP as part of the DOE Survey (DOE 1989); in 1994, 10 soil samples were collected throughout the entire pond.

Soil samples collected in 1986 were collected from approximately 13-cm (5-in.) bgs, the composite sample collected in 1987 was collected from 0 to 5 cm (0 to 2 in.) and from 5 to 10 cm (2 to 4 in.) bgs and the samples collected in the 1994 study were collected from 0 to 15 cm (0 to 6 in.) bgs. Soil samples collected as part of the DOE Survey were all subsurface samples collected from either 0.6 m (2 ft) or 1 m (3 ft).

Surface water samples were collected in 1987 and 1988. Analytical results for these samples are presented in Section 4.2.

**4.1.6.1 Metals**—Metals were analyzed for samples collected in each of the four studies. Of all the metals analyzed for in all the studies, 18 metals were retained from Table 3-8 for further evaluation as COPC. These metals are antimony, arsenic, cadmium, chloride, chromium, copper, fluoride, lead, manganese, mercury, nickel, nitrate, phosphate, selenium, silver, sulfate, vanadium, and zinc. No background concentration is available for chloride, nitrate, phosphate, silver; and sulfate therefore, any detection is considered to represent contamination. Section ANL-01—Industrial Waste Pond, shows that four of these inorganics (lead, manganese, nickel, and vanadium) are eliminated as COPCs since the statistics calculated 95% Upper Confidence Level (UCL) is below the INEEL background.

Antimony had only one out of the ten samples collected exceeding background. The concentration of this sample is 7.66 mg/kg and the INEEL background is 7.4 mg/kg.

All 10 detections of arsenic were greater than the upper limit of background (7.4 mg/kg). These concentrations ranged from 7.6 to 25 mg/kg. All but two of these detections were at locations sampled in

the 1994 study. The other two sample locations were both the surface and subsurface samples collected in 1987 (PND SED). The highest detection of arsenic was located at #101, which is just north of the inlet pipe.

Cadmium was detected in four locations at concentrations greater than the upper limit of background (3.7 mg/kg). These locations and their respective concentrations are #62 (4.3 mg/kg), #97 (7 mg/kg), #16 (4.7 mg/kg), and the surface sample at location PND SED (4.8 mg/kg). All four samples collected in the ANL-W study were not detected with a detection limit of 6 mg/kg. Cadmium was detected below the upper limit of background at location #30 in the western part of the pond and in samples located north of location #42.

Chromium was detected in all 22 samples with 13% of the detected concentrations greater than the upper limit of background (50 mg/kg). Concentrations ranged from 15.8 to 11,400 mg/kg. The highest concentration was detected at location #97, which is located near the inlet pipe, although concentrations greater than the upper limit of background were located throughout the IWP. Although the majority of the chromium contamination was located in the top 15 cm (6 in.) of soil, in subsurface samples, chromium concentrations ranged from 52 mg/kg at location #14 to 9,990 at location IWP INLET.

Copper was detected at concentrations greater than the upper limit of background in 50% of the samples analyzed. The highest concentrations of copper (137 mg/kg and 136 mg/kg) were detected at locations #97 and #101, respectively. These sample locations are just north of the inlet pipe. Copper was detected below the upper limit of background at location #30 in the western part of the pond and in samples located north of the DOE Survey's grid #29.

Lead was detected in four locations at concentrations greater than the upper limit of background (23 mg/kg). These locations and their respective concentrations are #76 (30.4 mg/kg), #95 (23.9 mg/kg), #101 (32.6 mg/kg), and the surface sample at location PND SED (23.1 mg/kg). All four samples collected in the ANL-W study were not detected with a detection limit of 30 mg/kg. Lead was detected below the upper limit of background at location #30 in the western part of the pond and in samples located north of location #62. This inorganic is eliminated as a COPC after determining that the UCL is less than the INEEL background.

Manganese exceeded the INEEL background (700 mg/kg) in only one sample at a concentration of 746 mg/kg. This contaminant is eliminated after the calculated UCL is less than the INEEL background.

Mercury was detected in 50% (9/18) of the samples analyzed with eight of these concentrations greater than the upper limit of background (0.074 mg/kg). The one location with a detection below background is #17, located about 46 m (150 ft) north of the inlet pipe. The maximum detected concentration (6.8 mg/kg) was detected at #97, approximately 30 m (100 ft) north of the inlet pipe. Mercury was not detected in #30 in the western part of the IWP. It should be noted that the detection limits were greater than the upper limit of background. Therefore, it is possible that mercury may be present at those locations, but still indicating notdetected mercury concentrations.

Nickel exceeded the INEEL background of 55 mg/kg in only two of the 18 samples that were collected. The maximum detected sample had a concentration of 65.2 mg/kg.

Selenium was detected at three locations at concentrations greater than the upper limit of background (0.34 mg/kg). These locations and their respective concentrations are #76 (1.6 mg/kg), #97 (3.3 mg/kg), and #101 (1.4 mg/kg). Two of these locations (#97 and #101) are in the vicinity of the inlet pipe, while #76 is approximately 76 m (250 ft) northwest of the inlet pipe. All of these sample locations are in the surface samples [0 to 15 cm (0 to 6 in.)]. Selenium concentrations north of PND SED and in

#30 in the western part of the ditch are less than the detection limits. It should be noted that the detection limits are greater than the upper limit of background.

Silver was detected in 12 of 22 samples. Because there is no background concentration available for silver, all detections are considered to be representative of contamination. Silver concentrations ranged from not detected (0.34 mg/kg) to 37.9 mg/kg. Silver was not detected in samples located north of DOE Survey #14, and it was not detected in the location in the western part of the IWP (#30). Silver was detected in one of the subsurface samples collected by ANL-W in 1986 at a concentration of 33 mg/kg. It should be noted that the majority (7/12) of the contamination was detected in the subsurface samples. Concentrations detected in the subsurface samples ranged from 2.8 to 33 mg/kg.

Vanadium was detected in all samples, and it was detected at concentrations greater than the upper limit of background (70 mg/kg) in only two samples. These sample locations and their respective concentrations are #97 (109 mg/kg) and #101 (71.8 mg/kg). Both of these detections were in surface samples [0 to 15 cm (0 to 6 in.)] and are located in the vicinity of the inlet pipe. Vanadium is eliminated as a COPC in the Industrial Waste Pond because the calculated UCL is less than the INEEL background.

Zinc was detected in all samples and it was detected at concentrations greater than the upper limit of background (220 mg/kg) in nine samples. Detected concentrations ranged from 58.5 to 5,850 mg/kg. The highest detection of zinc was at location #97. Zinc was detected below the upper limit of background at location #30 in the western part of the pond and north of location #14.

In addition five inorganics chloride, fluoride, nitrate, phosphate and sulfate which are typical indicator of human impacts to the environment were also analyzed. These five inorganics do not have background data and are retained for assessment in the risk assessment. These were all detected in 100 percent of the samples with the exception of one of the eight samples for sulfate.

**4.1.6.2 Radionuclides**—Gamma-emitting radionuclides were analyzed for in samples collected from within the IWP in the 1994 study and in three samples collected at the inlet pipe in 1990 and 1991. In addition, alpha-emitting radionuclides and Sr-90 were analyzed for in three samples. Soil samples collected from around the perimeter of the IWP were analyzed for Cs-137, Th-232, Ra-226, Pu-238, and Pu-239/240. Of all the radionuclides analyzed for in all the studies, only six exceeded the upper tolerance of background concentrations at a minimum of one sample location, or no background concentrations were available. These radionuclides are Cm-244, Co-60, Cs-137, Pu-239/240, Ra-226, and Sr-90. Background concentrations are not available for Cm-244, Co-60, and Ra-226; therefore, all detections of these radionuclides are considered to represent contamination.

All soil samples analyzed for radionuclides in the 1994 study were collected from 0 to 15 cm (0 to 6 in.). No information is available on the sample collection depth for the remaining samples.

Cm-244 was detected at a concentration of 0.11 pCi/g at location #101 in the southern part of the IWP near the inlet pipe.

Co-60 was detected at five of 12 samples. Detected concentrations range from 0.06 to 0.21 pCi/g. These concentrations were detected at sample locations #1 and #5 in the north part of the IWP and #42, in the central part of the IWP, and #76 and #95 in the southern part of the IWP.

Cs-137 was detected at all sample locations except for #14 and the perimeter sample by the inlet pipe in 1980. Detected concentrations ranged from 0.05 to 29.2 pCi/g. Cs-137 concentrations were greater than the upper limit of background (1.28 pCi/g) in nine of 21 samples. The highest detected

concentration was at location #101, which is located just north of the inlet pipe. Cs-137 concentrations typically decreased with increased distance from the inlet pipe. All sample locations along the perimeter of and in the western part of the IWP had Cs-137 concentrations less than the upper limit of background.

Pu-239/240 was detected in six samples, with only one sample at a concentration of 0.232 pCi/g exceeded the INEEL background of 0.19 pCi/g. This contaminant was eliminated as a COPC because the calculated UCL was less than the INEEL background.

Ra-226 was detected in all three of the samples it was analyzed for. The maximum detected sample was collected at location 52 and detected at 1.21 pCi/g. There is no background level for Ra-226, so any detection is considered to be above background. The calculated UCL is less than the INEEL background and the radionuclide is eliminated as a COPC.

Sr-90 was detected at one location at 2.5 pCi/g, which is greater than the upper limit of background (0.76 pCi/g). This location is #76, which is approximately 61 m (200 ft) northwest of the inlet pipe. Sr-90 was not detected at the two locations closest to the inlet pipe (#95 and #101).

**4.1.6.3 Organic Compounds**—The surface sample [0 to 15 cm (0 to 6 in.)] from the Chen Northern study was analyzed for VOCs, semi-VOCs, herbicides, pesticides, PCBs, and organophosphorus pesticides, and the six samples collected as part of the DOE Survey (DOE, 1989) were analyzed for VOCs. Organic compounds detected are 1,1,1-trichloroethane, 2,4,5-TP (silvex), 2-butanone, acetone, bis(2-ethylhexyl)phthalate, chloroform, di-n-butylphthalate, diethylphthalate, methylene chloride, and toluene. It should be noted that silvex was not analyzed for in soil samples collected from the different ditches that discharge into the IWP. Therefore, it is not known which ditch this herbicide was discharged to the IWP from.

Of these compounds, silvex was detected in only one sample (1-WP-M-5) at a concentration of 27,600 ug/kg. This sample was collected of a composite of sludge from three sample locations (A, B, and C). Di-n-butylphthalate, diethylphthalate, and bis(2-ethylhexyl)phthalate were also collected in this same sample at concentrations of 9, 2, and 8 ug/kg, respectively.

The 1,1,1-trichloroethane was detected in four of the six 1994 samples with concentrations up to 21 ug/kg. The 2-butanone was detected in all six 1994 DOE samples with concentrations ranging from 97 to 200 ug/kg. Acetone was detected in the 1987 sample and also in five of the six 1988 DOE samples with a concentration ranging from 79 to 130 ug/kg. The methylene chloride was detected in all seven samples and ranged from 27 to 300 ug/kg. The toluene was detected in two samples from 1988 DOE survey at concentrations of 3 and 5 ug/kg and were collected at locations #38 and #17 at depths of 72 cm (2.4 ft) and 90 cm (3.0 ft) respectively. The chloroform was also detected in two 1988 DOE samples at concentrations of 4 and 5 ug/kg at locations 29 and 38 and depths of 90 cm (3.0 ft) and 72 cm (2.4 ft) respectively.

**4.1.6.4 Extent of Contamination.** Using the information in the preceding three sections, the nature and extent of contamination to be used in the risk assessment can be determined. The majority of the contamination (i.e., detected organic compounds and concentrations of metals and radionuclides greater than the upper limit of background) is present in the southern and eastern part of the IWP with concentrations typically greatest near the inlet pipe in the southern part of the IWP. The highest number of metals above background were collected from location #101 with 11 metals exceeding background, then location # 97 with ten metals exceeding background. Therefore, the horizontal extent of contamination is the dimensions of both the southern and eastern part of the IWP [61 m wide and 76 m long (200 ft wide and 250 ft long).

Little information is available on the vertical extent of contamination because only six samples were collected at depths greater than 15 cm (0.5 ft). Also, the migration of contaminants from the surface sediments 0-15 cm (0-0.5 ft) to deeper sediments is difficult since only one sample location (PND SED) had samples collected from two depth ranges [0 to 5 cm (0 to 2 in.)] and [5 to 10 cm (2 to 4 in.)], and the deeper sample was only analyzed for metals. However, based on the analytical results of the 1988 DOE Survey and the results from the PND SED sample, it is assumed that the majority of the contamination is bound in the top 15 cm (6 in.). This trend is similar to all the drainage ditches which feed into the Industrial Waste Pond.

#### **4.1.7 OU 9-04: Industrial Waste Pond Ditch A (ANL-01—Ditch A)**

Soil samples were collected from the IWP Ditch A (herein after referred to as Ditch A) as part of two different investigations. These studies are the Chen Northern (1989) and the 1994 study. Section ANL-01—Ditch A of Appendix A shows the sampling location plan map, color intensity profile maps, scatter plots of the data, screening tables, statistics for COC by pathway, and combined data set for all samples collected from Ditch A. In the 1988, Chen Northern study, eight soil samples were collected from three locations in the western part of the ditch. In the 1994 study, 30 soil samples were collected from 11 locations throughout the entire length of the ditch.

Soil samples collected in 1988 were collected from approximately 0 to 1.2 m and 1.2 to 2.4 m (0 to 4 ft and 4 to 8 ft) bgs, whereas the soil samples collected in 1994 were collected from three depths. These depths typically consisted of a surface sample [0 to 1 cm (0 to 6 in.)]; a middle sample [usually from 1.1 to 1.2 m (3.5 to 4 ft) bgs]; and a subsurface sample collected at the top of basalt. Middle samples were collected from all but three sample locations. These sample locations are 20E, 21E, and 26E. The second sample collected at these locations was collected at the top of basalt, which was 1.1 to 1.2 m (3.5 to 4 ft) bgs at locations 20E and 26E. The sample collected at the top of basalt at location 21E was 0.6 to 0.8 m (2 to 2.5 ft). The last sample collected at the remaining seven locations ranged from 1.4 to 1.5 m (4.5 to 5 ft) in the eastern part of the ditch to 2.9 to 3.0 m (9.5 to 10 ft) in the western part of the ditch.

**4.1.7.1 Metals.** Metals were analyzed for samples collected in each of the two studies. Of all the metals analyzed for in both studies, only ten metals were retained as COPC as shown in Table 3-9. These metals are arsenic, chromium, copper, cyanide, lead, manganese, mercury, silver, thallium, and zinc. No background concentrations are available for cyanide or silver; therefore, any detection is considered to represent contamination.

Thirty seven percent (14 of 38) of arsenic samples were greater than the upper limit of background (7.4 mg/kg). These concentrations ranged from 7.6 to 11.7 mg/kg. Four of the samples that exceeded background were of surface samples, and the remaining 10 were subsurface samples. The highest detection of arsenic was a surface sample at location 4W, which is located the closest to the intersection of the Ditch A and the MCTBD. The MCTBD contains much higher levels of arsenic, which leached from green treated lumber used in the cooling tower.

Chromium was detected in all 38 samples with 32% (12 of 38) of the detected concentrations greater than the upper limit of background (50 mg/kg). Concentrations ranged from 10.0 to 548 mg/kg. Similar to the arsenic, the highest concentration was detected of a surface sample at location 4W, which is located nearest the MCTBD. Although the majority of the chromium contamination that exceeded background was located in the top 15 cm (6 in.) of soil, in subsurface samples, only four sample exceeded the background chromium concentration. These subsurface samples ranged from 50.5 mg/kg at location 26E to 161 mg/kg at location 8E.

Copper was only analyzed for in the 1994 sampling. Of the 30 samples collected, only 10 samples exceeded the upper limit of background. All 10 of the copper samples that exceeded the upper limit of background were collected of the surface samples [0 to 15 cm (0 to 6 in.)]. The highest concentration of copper (82.7 mg/kg) was detected at location #8E.

Cyanide was only analyzed for in the 1994 sampling. Cyanide was detected at three out of 30 locations in Ditch A 4W, 10W, and 18W. Concentrations of cyanide were 1, 0.46, and 8.4 mg/kg respectively. Two of the three cyanide samples (4W and 10W) were from surface samples [0 to 15 cm (0 to 6 in.)], and sample 18W was collected from the subsurface [2.85 to 3 m (9.5 to 10 ft)].

Lead was detected in five of 38 locations at concentrations greater than the upper limit of background (23 mg/kg). Four of the five samples were in the western portion of Ditch A. These locations and their respective concentrations are #4W (50.5 mg/kg), #10W (36.7 mg/kg), #18W (27.3 mg/kg), 31W (78.3 mg/kg), and 8E (58.8 mg/kg). All five samples that exceeded the upper limit of background were collected of the surface samples [0 to 15 cm (0 to 6 in.)] in the 1994 study. Lead is eliminated as a COPC because the calculated UCL is less than the INEEL background.

For manganese, only one sample out of 30 exceeded the background. This sample was detected at 773 mg/kg from sample location 8E in the 1994 study from a subsurface sample 1.35-1.5 m (4.5-5 ft) below grade. The background for manganese is 700 mg/kg. Manganese is eliminated as a COPC because the calculated UCL is less than the INEEL background.

Mercury was detected in 74% (27/38) of the samples analyzed. All of the mercury detections exceeded the upper limit of background (0.074 mg/kg). The maximum detected concentration (4.1 mg/kg) was detected at location #10W of the surface sample [0 to 15 cm (0 to 6 in.)]. In all but one instance, the surface samples at each location contained the highest concentrations of mercury with the exception of #26E. At #26E, the surface sample [0 to 15 cm (0 to 6 in.)] the concentration was 0.19 mg/kg, while the subsurface sample [1 to 1.2 m (3.5 to 4 ft.)] concentration was 0.86 mg/kg. Mercury was detected in only one of the three 1988 sample locations (A35) and was detected in both the surface and subsurface samples. It should be noted that all of the detection limits were greater than the upper limit of background. Therefore, it is possible that mercury may or may not be actually present.

Silver was detected in only 11 percent (4/38) of the samples. Because there is no background concentration available for silver, all detections are considered to be representative of contamination. Silver concentrations ranged from not detected (0.45 mg/kg) to 1.6 mg/kg. Silver was not detected in the eight 1988 samples. Of the four 1994 samples with detectable silver concentrations, all four were collected in the western portion of Ditch A, and were qualified as estimated values (J) by the chemist. It appears that there is no discrepancy between surface and subsurface silver concentrations.

Thallium was only analyzed in the thirty samples collected in 1994. Although the method detection limit for all 30 of the samples analyzed for thallium exceeded the upper limit of background (0.68 mg/kg), only one, sample #10W, had a detectable concentration. This detectable concentration was 1.6 mg/kg and was qualified as an estimated value (J) by the chemist. ANL-W does not have process knowledge of a release of thallium and will eliminate the thallium from the risk assessment calculations.

Zinc was detected in all 30 samples from 1994, and it was detected at concentrations greater than the upper limit of background (220 mg/kg) in 26 percent (8/30) of the samples. Detected concentrations ranged from 34.2 to 844 mg/kg. All of the eight samples that exceeded the upper limit of background were from surface samples [0 to 15 cm (0 to 6 in.)]. The highest detection of zinc was at location #8E. Only two out of the ten sample locations (26E and 35E), which are located on the south end of Ditch A, did not exceed the upper limit of background for their surface samples [0 to 15 cm (0 to 6 in.)].

**4.1.7.2 Radionuclides.** Gamma-emitting radionuclides were analyzed for all samples collected from Ditch A in the 1994 study. In addition, alpha-emitting radionuclides and Sr-90 were analyzed for at the highest two gamma emitting locations from the 1994 data. The radionuclides were compared with the 95%/95% upper limit of background for INEEL soils, and the only two radionuclides that were above these limits for Ditch A were two alpha-emitters, Sr-90 and U-238.

Sr-90 was detected at one location at 4.5 pCi/g, which is greater than the upper limit of background (0.76 pCi/g). This location is #35E, which is the farthest south sample location (i.e., closest to the outfall from the power plant building 768. Sr-90 was not detected at the other sampling location (#4W) closest to the MCTBD.

U-238 was detected at one location at 5.8 pCi/g, which is greater than the upper limit of background (1.85 pCi/g). This location is #4W, which is the closest sample location to the MCTBD. U-238 was not detected at location 35E.

**4.1.7.3 Extent of Contamination.** Using the information in the preceding two sections, the nature and extent of contamination to be used in the risk assessment can be determined. The contamination (i.e., concentrations of metals and radionuclides greater than the upper limit of background) depending on analyte is present throughout the entire Ditch A. It appears that some of the highest results were detected of soils closest to the intersection of the MCTBD and Ditch A. Typically, the concentrations of contaminants typically are the highest in the surface 0 to 15 cm (0 to 6 in.) samples. The one exception to this is of the three samples for silver, for which the deeper samples contained the only detectable levels. Therefore, the horizontal extent of contamination is the dimensions of both the eastern and western part of Ditch A [1.5 m wide and 122 m long (5 ft wide and 400 ft long)].

The vertical contamination in Ditch A was determined to be contained within the surface soils 0–15 cm (0–6 in.). But, for cyanide, the contamination was detected at deeper locations than the surface soils. A review of the operating history and process knowledge, show that cyanide is not a known COPC.

#### **4.1.8 OU 9-04: Industrial Waste Pond Ditch B (ANL-01—Ditch B)**

Soil samples were collected from the IWP Ditch B (herein after referred to as Ditch B) as part of three different investigations. Six soil samples were collected from the 1988 DOE study, 15 samples collected from the 1988 Chen-Northern study, and 10 samples in the 1994 ANL-W study. Section ANL-01—Ditch B of Appendix A shows the sampling location plan map, color intensity profile maps, scatter plots of the data, screening tables, statistics for COC by pathway, and combined data set for all samples collected from Ditch B.

In the 1988 DOE study, two subsurface soil samples [(1.8 to 4.1 m (6 to 13.5 ft.)) were collected from each of three different locations. Also, in 1988, nine shallow [0 to 1.2 m (0 to 4 ft.)) composite soil samples were collected and six deep [1.2 to 2.4 (4 to 8 ft.)) composite samples were collected. In 1994, 10 soil samples were collected, five from the surface 0 to 15 cm (0 to 6 in.) bgs and five of the subsurface 15 to 39 cm (6 to 13.5 in.) throughout the still used portion of Ditch B.

Surface water samples were collected in 1987 and 1988. Analytical results for these samples are presented in Section 4.2.

**4.1.8.1 Metals.** Metals were analyzed for samples collected in each of the three studies. Of all the metals analyzed for in all the studies, only 13 metals were retained as COPCs from Table 3-10. These metals are arsenic, barium, beryllium, cadmium, chromium, copper, lead, manganese, mercury, nickel,



selenium, silver, and zinc. No background concentration is available for silver; therefore, any detection is considered to represent contamination.

For arsenic, of the 31 samples that were analyzed, 10 were greater than the upper limit of background (7.4 mg/kg) with an additional six samples having non-detects. These detected concentrations ranged from 5 to 14 mg/kg. Four of the detects that exceeded background were from the 1988 Chen-Northern study and the remaining six from the 1994 ANL-W study. Of the six samples collected in the 1988 DOE study, all results were qualified as non-detects. The method detection limits for the non-detects exceeded the upper limit of background. The highest detection of arsenic was located at #3, which is the farthest west samples collected of the portion of Ditch B, which is still open. The thickness of the alluvium in Ditch B varies from less than 61 cm (2 ft) in the still-used portion, to up to 2.4 m (8 ft) in the buried portion.

For barium, only one sample exceeded the upper limit of background (440 mg/kg). This sample was detected at 1,690 mg/kg and was a composite sample from the soil 0 to 97 cm (0 to 3.2 ft) collected in 1988 by Chen-Northern at location D70B in the buried portion of Ditch B. Barium is eliminated as a COPC because the calculated UCL for barium is less than the INEEL background concentration.

Like barium, beryllium exceeded the upper limit of background (3.0 mg/kg) in only 3.2 percent (1/31) of the samples. This sample was detected at 3.9 mg/kg and was a composite sample from the soil 0 to 97 cm (0 to 3.2 ft) collected in 1988 by Chen-Northern at location D70B in the buried portion of Ditch B. Beryllium is eliminated as a COPC because the calculated UCL for beryllium is less than the INEEL background concentration.

Cadmium exceeded the INEEL background concentration of 3.7 mg/kg in only one sample with a concentration of 4.0 mg/kg. Cadmium is eliminated as a COPC because the calculated UCL for cadmium is less than the INEEL background concentration.

Chromium was detected in all 31 samples with 45% (14/31) of the detected concentrations greater than the upper limit of background (50 mg/kg). Concentrations ranged from 13.4 to 4,530 mg/kg. The highest concentration was detected at location #3, which is the farthest west location in the still-used portion of Ditch B. The highest 12 of the 14 samples (86%) are located in the still used portion of Ditch B. Only two samples D81CD and D42CS in the buried portion of Ditch B exceeded the upper limit of background (50 mg/kg) with levels of 386 and 62.2 mg/kg, respectively.

Copper was analyzed in 17 samples: Six from 1988 DOE, one from the 1988 Chen-Northern, and 10 from the 1994 study. The copper exceeded the upper limit of background (32 mg/kg) in 53% (9/17) of the samples analyzed. All nine of these samples were from the still-used portion of Ditch B collected in the 1994 ANL-W study. The highest concentration of copper was 216 mg/kg and was detected at location #28.

Lead was detected in nine locations at concentrations greater than the upper limit of background (23 mg/kg). Eight of these nine samples were from the 1994 ANL-W study collected from the still-used portion of Ditch B. The concentration for the lead ranged from 5.6 to 50.2 mg/kg with the highest sample location being #3 in the western portion of the still-used portion of Ditch B. Only one sample in the buried portion of Ditch B exceeded the upper limit of background (23 mg/kg). This was location D63BS with a concentration of 34 mg/kg.

Manganese exceeded the INEEL background concentration of 700 mg/kg in only one sample with a concentration of 705 mg/kg. Manganese is eliminated as a COPC because the calculated UCL for manganese is less than the INEEL background concentration.

Mercury was detected in 29% (9/31) of the samples analyzed, with all nine of these concentrations greater than the upper limit of background (0.074 mg/kg). Four of the nine samples were collected from the buried Ditch B (D104BD, D81CD, D70BS, and D42CS), and the remaining five samples were collected from the buried Ditch B (28, 29, 29, C3BS, and C3BD). The maximum detected concentration (4.1 mg/kg) was detected in buried Ditch B at location #28, approximately 15 m (50 ft) downgradient from the inlet pipe. It should be noted that for 16 of the non-detect samples, the detection limits were greater than the upper limit of background. Therefore, it is possible that these mercury concentrations may be present above the upper limit of background.

Nickel exceeded the INEEL background concentration of 55 mg/kg in only one sample with a concentration of 62.4 mg/kg. Nickel is eliminated as a COPC because the calculated UCL for nickel is less than the INEEL background concentration.

Selenium was detected at only one location at concentrations greater than the upper limit of background (0.34 mg/kg). This location was D70BS with a concentration of 0.45 mg/kg. This was a composite sample from 0 to 97 cm (0 to 3.2 ft) in the buried portion of Ditch B. The remaining 96.7% (30/31) of the samples had non-detects values for selenium. It should be noted that the detection limits are greater than the upper limit of background.

Silver was detected in 29% (9/31) samples. Because there is no background concentration available for silver, all detections are considered to be representative of contamination. Silver concentrations ranged from not detected (0.42 mg/kg) to 1.1 mg/kg. All 10 samples, from the 1994 ANL-W study of the still-active portion of Ditch B, were lab qualified as non-detects. Only one sample (D3BS) from the still active portion of Ditch B had an actual detection of silver (0.63 mg/kg). Of the samples collected from the buried portion of Ditch B, 83.3% (5/6) of the 1988 DOE samples and 21% (3/14) of the 1988 Chen-Northern had actual detection of silver. Thus, it appears that the majority of the actual silver detections are from the buried portion of Ditch B.

Zinc was detected in all 17 samples. Zinc exceeded the upper limit of background (220 mg/kg) in 58.8% (10/17) samples. All 10 of these samples were from the 10 samples collected in the 1994 ANL-W study of the still-active portion of Ditch B. Detected concentrations ranged from 602–3,020 mg/kg. The highest detection of zinc was at location #97. Zinc was not detected above the upper limit of background for any of the seven samples of the buried portion of Ditch B.

**4.1.8.2 Radionuclides.** Gamma-emitting radionuclides were analyzed for the eight samples collected from Ditch B in the 1994 study. Six out of the eight Cs-137 samples contained detectable levels. All of these six results were below the upper limit of background for Cs-137. In addition, alpha-emitting radionuclides and Sr-90 were analyzed for in one sample with the highest gamma-emitting radionuclides. All the alpha-emitting radionuclides for sample 01B-64 at location #12 were non-detects. Thus, Ditch B contains no gamma- or alpha-emitting radionuclides in the currently operating portion of Ditch B.

**4.1.8.3 Organic Compounds.** One sample D70BS, collected in the 1988 Chen-Northern study, was analyzed for VOCs, semi-VOCs, dioxin/furans, herbicides, pesticides, PCBs, and organophosphorus pesticides under Appendix VIII analysis. Six samples collected as part of the DOE Survey (DOE 1989) were analyzed for VOCs. Of the up to seven samples for Ditch B, the only organic compounds detected are 1,1,1-trichloroethane, 2,4-D, acetone, Di-n-butylphthalate, methylene chloride, and bis(2-Ethylhexyl) phthalate.

The VOCs compounds that were detected are 1,1,1-trichloroethane, acetone, and methylene chloride. The methylene chloride was detected in 57% (4/7) samples (D70BS, #23, and both depths at #46) with maximum concentration of 23 ug/kg from location D70BS. Acetone was detected in 43% (3/7)

of the samples (D70BS, #7, and #46) with the maximum concentration of 25 ug/kg at #7 of 25 ug/kg. The 1,1,1-trichloroethane was found in one sample D70BS 14% (1/7) with a concentration of 6 ug/kg. Thus, sample location D70BS contained all three VOCs and was collected over a depth range of 0 to 97 cm (0 to 3.2 ft). Location #46 contained two hits for methylene chloride, and one hit for acetone and the depth ranges from 1.83 to 2.29 m (6 to 7.5 ft) to 3.35 to 3.81m (11 to 12.5 ft). Also, it must be mentioned that both methylene chloride and acetone are common laboratory contaminants and can be removed during validation.

In the 1988 Chen-Northern study, the one sample D70BS at Ditch B that was collected from 0 to 97 cm (0 to 3.2 ft) had hits for herbicides, bis(2-ethylhexyl)phthalate, and di-n-butylphthalate. The herbicides 2,4-D was identified at a level of 87 ug/kg. The semi-VOCs, bis(2-ethylhexyl)phthalate, and di-n-butylphthalate were identified at 120 and 350 ug/kg, respectively. The phthalates are common laboratory contaminants, which are typically caused from plastics (i.e., sample bottles).

**4.1.8.4 Extent of Contamination.** Using the information in the preceding three sections, the nature and extent of horizontal contamination to be used in the risk assessment can be determined. The majority of the metals contamination greater than the upper limit of background is present in the still used portion of Ditch B. This could be caused from the lack of samples in the buried portion of Ditch B, or the large sampling ranges of the soils. Ditch B was only sampled for organics in the buried portion. Thus, the only organic contamination detected was in this section. The organic contamination detected included three VOCs (1,1,1-trichloroethane, acetone, and methylene chloride), one herbicide (2,4-D), and two semi-VOCs (bis(2-ethylhexyl)phthalate and di-n-butylphthalate), which are common laboratory contaminants. No radionuclides were detected above the upper limit of background in either portion of Ditch B. Therefore, based on the lack of continuous sampling of the buried and still-used portions of Ditch B, the horizontal extent of contamination is the dimensions of both sections of Ditch B [1.5 m wide and 427 m long (5 ft wide and 1,400 ft long)].

The information in the preceding three sections was used to determine the nature and extent of the vertical contamination in Ditch B. The two sections of Ditch B (buried and still used portions) are inherently different in the depth ranges of the alluvium material on top of the basalt. In the still-used portion of Ditch B, the thickness of this alluvium 39 cm (1.3 ft) is fairly constant. In the buried portion of Ditch B, the depth of the alluvium varies from 0.39 to 4.1m (1.3 to 13.5 ft). No stratification of metals or organics was determined from the results in either the still-in-use portion or the buried portion of Ditch B. The vertical extent will have to use the depth of the alluvium to the basalt in each portion of Ditch B.

#### **4.1.9 OU 9-04: Industrial Waste Pond Ditch C (ANL-01—Ditch C)**

A total of 24 soil samples were collected from the IWP Ditch C (herein after referred to as Ditch C) as part of three different investigations. Three samples were collected from the 1988 DOE study, six samples collected from the 1988 Chen-Northern study, and 15 samples from the 1994 ANL-W study. Section ANL-01—Ditch C of Appendix A shows the sampling location plan map, color intensity profile maps, scatter plots of the data, screening tables, statistics for COC by pathway, and combined data set for all samples collected from Ditch C.

The three 1988 DOE samples were composite samples collected over a sampling range of 0 to 71 cm (0 to 2 ft). Also, in 1988, of the six Chen-Northern samples, five were composite samples collected in the range of 0 to 1.2 m (0 to 4 ft) and one deep composite sample collected at 1.2 to 2.4 m (4 to 8 ft). In 1994, of the 15 soil grab samples collected, eight were from the surface samples 0 to 15 cm (0 to 6 in.) bgs and the remaining seven of the subsurface samples 15 to 76 cm (0.5 to 2.5ft).

**4.1.9.1 Metals.** Metals were analyzed for samples collected in each of the three studies. Of all the metals analyzed for, 16 metals are retained as COPCs as shown in Table 3-11. These metals are arsenic, chloride, chromium, copper, cyanide, fluoride, lead, mercury, nitrate, phosphate, selenium, silver, sulfate, thallium, and zinc. No background concentration is available for chloride, cyanide fluoride, nitrate, phosphate, silver and sulfate; therefore, any detection is considered to represent contamination. Four inorganics (chromium, copper, lead, and zinc) are eliminated as COPCs because the UCL calculated in Appendix A is less than the INEEL background.

The concentrations of arsenic ranged from 3.9–12.8 mg/kg with 17% (4/24) of the samples exceeding the upper limit of background (7.4 mg/kg). In addition, the three samples collected in the 1988 DOE study were non-detects with the method detection limit greater than the upper limit of background. The four samples that exceeded background were collected in 1994 at grid locations #1, #12, and two samples at #53. Their respective concentrations are 12.8, 8.3, 10.3, and 12.1 mg/kg, respectively. Three of the four samples (#1, #12, and #53) were collected of surface samples 0 to 15 cm (0 to 0.5 ft) with a subsurface sample collected at 15 to 30 cm (0.5 to 1 ft) at grid location #53.

Chloride, fluoride, nitrate, phosphate, and sulfate were detected in all three samples collected. These are being retained for further evaluation since no INEEL background exists.

Chromium was detected in all 22 samples with 12.5% (3/24) of the detected concentrations greater than the upper limit of background (50 mg/kg). Concentrations ranged from 11.3 to 131 mg/kg. The highest concentration was detected in 1994 of a surface sample 0 to 15 cm (0 to 0.5 ft) at location #82. The other two samples were detected at concentrations of 63.5 and 51 mg/kg and were collected at sample locations #1 and grid #9 at a depth of 0 to 15 cm (0 to 0.5 ft) and 0 to 45 cm (0 to 1.5 ft). Thus, the chromium contamination appears bound in the surface soils of Ditch C.

Copper was analyzed for in 18 samples from Ditch C. Of these 18 samples, only four were detected at concentrations greater than the upper limit of background (32 mg/kg). The highest concentration of copper was 59 mg/kg at grid location #9. This sample was collected in 1988 at a depth of 0 to 45 cm (0 to 1.5 ft). The three other samples that exceeded the upper limit of background were collected of surface samples 0 to 15 cm (0 to 0.5 ft) at locations #82, #1, and #12 with concentrations of 34.9, 33, and 37.9 mg/kg. These three samples are less than the 95%/99% upper tolerance limit (40 mg/kg) for copper.

Cyanide was detected in 5 of 15 samples collected in 1994. Because there is no background concentration available for cyanide, all detections are considered to be representative of contamination. The detectable cyanide concentrations ranged from 0.43 to 12.2 mg/kg. Cyanide was detected in two shallow samples 0 to 15 cm (0 to 0.5 ft) at locations #32 and #53, while the three subsurface samples 15 to 60 cm (0.5 to 2 ft) were collected at locations #1, #30, and #32.

Lead was analyzed for in all three studies and detected in 12.5% (3/24) of samples at concentrations greater than the upper limit of background (23 mg/kg). These three samples were collected in surface samples 0 to 15 cm (0 to 0.5 ft) from the 1994 sampling. The locations and their respective concentrations are #1 (40.5 mg/kg), #12 (24.3 mg/kg), and #32 (23.1 mg/kg). It should be noted that two of these samples from locations #12 and #32 are less than the 95%/99% upper tolerance limit (27 mg/kg) for lead.

Mercury was detected in 42% (10/24) of the samples analyzed from the three studies. Approximately 93% (22/24) of samples collected had method detection limits greater than the upper limit of background (0.074 mg/kg) for mercury. The two samples (grid 29 and grid 49) with detections less than the upper limit of background were collected in the 1988 DOE study. The maximum detected

concentration for mercury is 0.83 mg/kg and was detected at location #1 at a depth of 0 to 15 cm (0 to 0.5 ft). It should be noted that most of the detection limits were greater than the upper limit of background. Therefore, it is possible that mercury may be present at those locations but still indicating not detected mercury concentrations.

Selenium was detected at three locations at concentrations greater than the upper limit of background (0.34 mg/kg). These locations and their respective concentrations are #1 (0.61 mg/kg), #32 (0.49 mg/kg), and #53 (0.55 mg/kg). It should be noted that all of the non-detects had method detection limits that were greater than the upper limit of background.

Silver was detected in 17% (4/24) of samples collected from the three studies. Because there is no background concentration available for silver, all detections are considered to be representative of contamination. Detected silver concentrations ranged from 0.47–7.3 mg/kg. The highest detect for silver was collected in the 1994 study at location #15, and a depth range of 60 to 75 cm (2 to 2.5 ft). Of the silver detects, two were collected in the 1988 DOE study, one in the 1988 Chen-Northern study, and one in the 1994 study.

Thallium was analyzed for in only the 1994 study. The method detection limit exceeded the upper limit of background (0.68 mg/kg) for all 15 thallium samples. Only one sample had a true detection; the other 14 were qualified as non-detects. This sample location and concentration is #32 (1.5 mg/kg). This sample was collected of a surface sample 0 to 15 cm (0 to 0.5 ft) straight west of the cooling tower.

Zinc was detected in all 18 samples, and it was detected at concentrations greater than the upper limit of background (220 mg/kg) in only one sample. This detection was of a surface sample 0 to 15 cm (0 to 0.05 ft) at location 82 and concentration of 312 mg/kg. The 95%/99% upper tolerance limit for zinc is (270 mg/kg), and the one detection of zinc at 312 mg/kg may statistically be within range.

**4.1.9.2 Radionuclides.** Radionuclides were analyzed at 15 soil samples in the 1994 study and for all three samples for the DOE survey (DOE 1989). All 15 samples collected in 1994 were analyzed for gamma-emitting radionuclides, and the two highest gamma-emitting samples were analyzed for alpha-emitting radionuclides. From the 1994 radionuclide analysis, only one U-238 sample exceeded the upper limit of background. The three samples from the 1988 DOE survey were analyzed for gross alpha, gross beta, Cs-137, Co-60, H-3, K-40, and Sr-90. Gross alpha and gross beta concentrations ranged from 3.3 to 3.5 pCi/g and 3.6 to 7.0 pCi/g, respectively. Co-60 was not detected in the three sample locations for the DOE survey. Tritium was also detected in all three samples collected from the DOE survey. Tritium concentrations ranged from 1.7 to 2.6 pCi/g. There are no background concentrations available for gross alpha, gross beta, Co-60 or tritium and they are retained as COPCs. These radionuclides that are retained as COPCs are discussed below.

Gross alpha, gross beta, and tritium are retained as COPCs from Table 3-11. Each of these samples had positive detections for all three samples from the 1988 DOE survey. These radionuclides are retained because no INEEL background exists.

The Co-60 was analyzed 18 times from the different studies. Only three of the 18 samples had true positive detections with a maximum sample of 0.029 pCi/g. The radionuclide is retained as a COPC for further evaluation in the risk assessment because no INEEL background exists.

Of the two samples analyzed for U-238 in 1994, only one exceeded the upper limit of background (1.85 pCi/g). This sample was collected at location #53 with a concentration of 21 pCi/g and depth of 0 to 15 cm (0 to 0.5 ft)

**4.1.9.3 Organic Compounds.** Three samples from the DOE survey (DOE 1989) were analyzed for organic compounds. Organic compounds detected are 1,1,1-trichloroethane (1,1,1-TCA), acetone, methylene chloride, chloroform, 2-butanone, and toluene. Of these compounds, only 1,1,1-Trichloroethane, methylene chloride, and 2-butanone were detected in all three sample locations at concentrations ranging from 11 to 56 ug/kg, 120 to 170 ug/kg, and 100 to 110 ug/kg, respectively. Chloroform was detected in only one of the three samples with a concentration of 0.003 mg/kg. Toluene was detected in two samples with a maximum concentration of 0.004 mg/kg. Acetone was detected in only two of the three samples at concentrations ranging from 42 to 69 ug/kg. Acetone and methylene chloride are common laboratory contaminants and may indicate laboratory contamination and not contamination of Ditch C.

**4.1.9.4 Extent of Contamination.** Using the information in the preceding three sections, the nature and extent of contamination to be used in the risk assessment can be determined. The majority of the contamination (i.e., detected organic compounds and concentrations of metals and radionuclides greater than the upper limit of background) is present in the northern part of Ditch C. This is may be because this area is closest to the MCTBD and water may back up into Ditch C. Of the samples that had contaminants greater than background for metals, location #1 had the highest detects above background with six contaminants (arsenic, chromium, copper, lead, mercury, and selenium). Typically, the sample locations on the southern end of Ditch C only exceeded the upper limit of background for only one or two contaminants. For radionuclides, no variations in horizontal contamination can be determined, since only one true hit for U-238 was above background. The horizontal extent of the organic contamination cannot be determined since only three samples were collected in the same general area. Therefore, the horizontal extent of contamination is the total dimensions of Ditch C [1.5 m wide and 152 m long (5 ft wide and 500 ft long)].

Little information is available on the vertical extent of contamination because most of Ditch C is fairly shallow and only 45 cm (2 ft) for most of the northern portion. However, a couple of samples on the southern end of Ditch C were collected at depths ranging to 2.4 m (8 ft). This one subsurface sample exceeded the upper limit of background only for mercury. This sample was detected at 0.13 mg/kg while the upper limit of background is 0.074 mg/kg. This one hit for contamination at this depth may be caused more by the low detection limit for mercury rather than actual contamination. Thus, the vertical extent of the contamination is the depth of the contaminant other than mercury. This would be the depth of silver, which was detected to a depth of 60 to 75 cm (2 to 2.5 ft). Most of this contamination was in the surface samples 0 to 15 cm (0 to 0.5 ft).

#### **4.1.10 OU 9-04: Main Cooling Tower Blowdown Ditch (ANL-01A—MCTBD)**

This section summarizes the analytical results for soil samples collected at the Main Cooling Tower Blowdown Ditch (MCTBD). As discussed in Section 3.1.1.4.2, this ditch was used to transport cooling tower water from the EBR II Reactor to the Industrial Waste Pond. Regeneration wastes from the demineralization columns were also discharged to this ditch. Therefore, all soil samples collected were analyzed for metals.

Section ANL-01A—MCTBD of Appendix A shows the sampling location plan map, color intensity profile maps, scatter plots of the data, screening tables, statistics for COC by pathway, and combined data set for all samples collected from the MCTBD. Soil samples were collected from the MCTBD as part of four different investigations occurring from 1987 to 1994. In 1987, one soil sample (EST-SED) was collected from the northern part of the ditch where a storm water discharge ditch flows into it. In 1988, six soil samples were collected from the different parts of the ditch. Three soil samples were collected from the west part of the ditch (C103B-S, C100B-S,D, and C73A-S), one sample was collected in the eastern portion of the ditch at the discharge point (B6B-S,D), and two soil samples

(D124B-S and D117C-S) were collected from the part of the ditch that, at one time, connected to the Industrial Waste Pond's Ditch B. This part of the ditch is hereinafter referred to as Old Ditch D. In 1989, two soil samples (M-8 and M-10) were collected in the 14-m (45-ft) interbed along the western portion of the ditch. Finally, in 1994, 35 samples were collected along the entire length of the ditch, excluding the Old Ditch D.

Soil samples collected in 1988 were collected from the surface to the depth of basalt, which ranged from 0–0.6 m to 1.2 m (0–2 ft to 4 ft). When the depth to basalt was deeper than approximately 1.2 m (4 ft), an additional sample was collected from 1.2 to 2.4 m (4 to 8 ft). In 1994, a surface sample [0 to 15 cm (0 to 6 in.)] was collected from each sample location along with at least one additional subsurface sample. The number of subsurface samples collected at each depth was also dependent on the depth to basalt. Depths of subsurface samples collected in the 1994 study ranged from 0.3–0.5 m to 1.7–1.8 m (1–1.5 to 5.5–6 ft).

**4.1.10.1 Metals.** Of all the metals analyzed for in all the studies, only 15 metals are retained as COPCs from Table 3-12. These metals are antimony, arsenic, beryllium, chromium, cobalt, copper, cyanide, lead, manganese, mercury, nickel, selenium, silver, vanadium, and zinc. No background concentrations are available for cyanide and silver; therefore, any detection is considered to represent contamination. Five metals are eliminated as COPCs based on the results of the calculated UCL values are less than the INEEL background concentrations. These five metals are beryllium, cobalt, manganese, nickel, and vanadium.

Scatter plots were prepared to illustrate the concentration of the metals based location relative to the discharge point. These scatter plots are presented in Section ANL-01A—MCTBD of Appendix A. The 95%/95% upper tolerance limit on background concentrations, when available, is presented on each scatter plot to indicate which detections of the metals were detected at concentrations greater than the upper limit of background and will be evaluated in the risk assessment.

Eight of the antimony results from the 1994 study are “R” flagged and are rejected from use in this evaluation. Of the remaining 31 sample locations, eight have concentrations greater than the upper tolerance limit of background (7.4 mg/kg). These locations are all in the western portion of the ditch with concentrations ranging from 6.22 to 56.1 mg/kg. All but one detection were greater than background, and there were several non-detections greater than background. The majority of the concentrations detected were in the surface samples collected. It should be noted that when antimony concentrations exceeded the upper limit of background in subsurface samples, the concentration in the subsurface sample decreased from the concentration in the surface sample. Antimony was not detected in the 14-m (45-ft) interbed.

Arsenic concentrations exceeded the upper tolerance limit of background (7.4 mg/kg) in 40% of the samples collected. Arsenic concentrations ranged from not detected to a maximum concentration of 74.6 mg/kg. The highest concentrations of arsenic were detected in the eastern side of the ditch and decreased in the western side until after the confluence with the North Ditch (ANL-35) where approximately 50% of the samples had arsenic concentrations greater than the upper limit of background. The majority of the arsenic concentrations greater than the upper limit of background were detected in the surface samples. Arsenic was detected at concentrations less than the upper limit of background in the 14-m (45-ft) interbed.

Beryllium exceeded the INEEL background concentration of 3 mg/kg in only one sample with a concentration of 4.2 mg/kg. Beryllium has been eliminated as a COPC based on the calculated UCL value being less than the INEEL background.

Approximately 37% of the samples analyzed exceeded the upper limit of background (50 mg/kg) for chromium. Chromium was detected in the highest concentrations at the discharge point into the ditch and overall decreased along the length of the ditch. The highest detected concentration of chromium is 2,200 mg/kg and was detected at in the surface sample [0 to 15 cm (0 to 6 in.)] for location 16E. Typically, chromium concentrations decreased with increased depth. However, at location 11E, chromium concentrations were similar in both the surface (512 mg/kg) and subsurface samples (563 mg/kg). Chromium concentrations were below the upper limit of background in the 14-m (45-ft) interbed.

Thirty-nine percent of the copper concentrations exceeded the upper limit of background (32 mg/kg) with the highest concentration (999 mg/kg) from the surface sample [0 to 15 cm (0 to 6 in.)] at location 9E. Approximately 58% of the samples collected in the east part of the ditch exceeded background, whereas only 32% of the copper concentrations exceeded background in the western part of the ditch. In all samples with copper concentrations greater than the upper limit of background in the western part of the ditch, the concentrations decreased to below background in the subsurface sample. This trend was noted in the eastern part of the ditch for the majority of the sample locations except for locations 4E and 11E. At these locations copper concentrations were above background in both the surface sample and the deepest sample collected at each location (99.5 to 41.7 mg/kg and 57.5 to 82.7 mg/kg, respectively). Copper concentrations were below the upper limit of background in the 14-m (45-ft) interbed.

Cyanide was detected at four locations along the entire length of the MCTBD. These concentrations ranged from 0.78 to 12.6 mg/kg. The maximum detected cyanide concentration was detected in the surface sample at location 9W, two detections (0.78 and 1.8 mg/kg) of cyanide were in the surface [0 to 15 cm (0 to 6 in.)] and subsurface sample [1.1 to 1.2 m (3.5 to 4 ft)] at location 41W, and the final detection of cyanide was in the surface sample [0 to 1.2 m (0 to 4 ft)] at location C103BS (6.3 mg/kg). Cyanide was also detected in both samples collected from the 14-m (45-ft) interbed at concentrations of 0.15 and 0.19 mg/kg. No background concentration is available for cyanide in soil.

Thirty-three percent of the lead concentrations exceeded the upper limit of background (23 mg/kg) with the highest concentration (138 mg/kg) from the surface sample at location 11E. Lead concentrations were highest in the eastern part of the ditch and the southern end of the western part of the ditch. Lead concentrations were below the upper limit of background in the 14-m (45-ft) interbed. Lead concentrations decreased with increased depth to below the upper limit of background at all locations except for 11E. At this location, the lead concentration decreased from 138 mg/kg in the surface sample to 57.4 mg/kg in the subsurface sample.

Manganese concentrations only exceeded the upper limit of background (700 mg/kg) at four of the 36 samples analyzed. These concentrations ranged from 810 to 1,180 mg/kg and were detected in the subsurface samples collected at locations 4E, 49W, 19W, and 9W. At locations 4E and 9W the concentrations above the upper limit of background (1,180 mg/kg and 1,050 mg/kg, respectively) were detected in the 1.1 to 1.2 m (3.5 to 4 ft) bgs sample and the manganese concentrations were below background in the next deepest sample [1.5 to 1.7 m (5 to 5.5 ft) and 1.7 to 2.0 m (5.5 to 6.0 ft), respectively]. At locations 19W and 49W the manganese concentrations detected above background (810 mg/kg and 970 mg/kg, respectively) were detected in the deepest sample collected at each location.

Forty-eight percent (22/46) of the mercury concentrations exceeded the upper limit of background (0.074 mg/kg) ranging from 0.08–13.4 mg/kg. The highest detected concentration was from the surface sample at location 9E. Mercury concentrations were highest in the eastern part of the ditch and typically decreased to less than one mg/kg in the subsurface sample except for one location. At location 11E, mercury concentrations were 2.8 mg/kg in the surface and 2.3 mg/kg in the subsurface sample. Mercury



was detected in one of the two samples collected at the 14-m (45-ft) interbed at a concentration less than the upper limit of background.

Nickel was detected above the upper limit of background concentration (55 mg/kg) in four samples collected. These four locations are located in the eastern part of the ditch, and their respective concentrations are 9E (540 mg/kg), 10E (134 mg/kg), 11E (84.3 mg/kg), and 16E (69.4 mg/kg). The only location where background was exceeded in a subsurface sample was at 11E. All the remaining detections greater than background were in surface samples [0 to 15 cm (0 to 6 in.)] collected. Nickel concentrations did not exceed the upper limit of background in the 14-m (45-ft) interbed.

Selenium was detected at four locations in the MCTBD. These locations and their respective concentrations are 10E (1.3 mg/kg), 9W (1.5 mg/kg), 22W (2.2 mg/kg), and 41W (1 mg/kg). All detections were in the surface sample and selenium was not detected in any subsurface sample or any sample from the 14-m (45-ft) interbed. It should be noted that the detection limits for selenium are greater than the upper limit of background (0.34 mg/kg). Therefore, because there are some non-detects of selenium at concentrations greater than the upper limit of background and the detections of selenium, it is possible that selenium may be present at locations where they were previously not detected.

Silver was detected at 15 of 44 samples at concentrations ranging from 0.86 to 94.7 mg/kg. The majority of the silver detections (73%) were detected in surface samples. These detections were in the eastern part of the ditch and again after the confluence with the North Ditch (ANL-35) in the western part of the ditch. Silver was detected at a concentration of 20 mg/kg in the surface sample collected from location 9W, and the silver concentrations at the two subsurface samples at that location were "R" flagged and are not used in the evaluation. At four locations, silver concentrations either increased with increased depth or the concentrations remained the same at both depth. These locations and their respective surface and subsurface concentrations are 22W (not detected in the surface sample and 14.9 mg/kg in the subsurface sample), 7E (2.7 mg/kg in both surface and subsurface samples), B6 (0.86 mg/kg and 0.96 mg/kg), and 11E (not detected in the surface sample and 6.8 mg/kg in the subsurface sample). Silver was not detected in the samples collected from the 14-m (45-ft) interbed. No background concentration is available for silver in soil.

Vanadium exceeded the INEEL background concentration of 70 mg/kg in only one sample with a concentration of 74.1 mg/kg. The calculated UCL value for vanadium is less than the INEEL background and vanadium has been eliminated as a COPC.

Zinc was detected in nine of 39 samples at concentrations greater than the upper limit of background (220 mg/kg). These concentrations ranged from just above the upper limit of background (222 mg/kg) to 2,130 mg/kg. All but one of these detections were in the surface samples and the one detection greater than background that was collected in the subsurface sample was at location 11E. The concentration in this sample is just barely above background (222 mg/kg). The highest detected zinc concentrations and the highest percentage of were located in the eastern part of the ditch, but there were also detections greater than background in the western part of the ditch. Zinc was not detected at concentrations greater than the upper limit of background in the samples collected from the 14-m (45-ft) interbed.

**4.1.10.2 Organics.** Two samples were collected of the soils in the MCTBD and analyzed for the complete list of 40 CFR 26 Appendix VIII analysis. These samples are C103BS collected on September 30, 1998 and EST-SED which was collected on January 1, 1997. The samples were collected over the depth ranges of 0-120 cm (0-4 ft) and 0-15 cm (0-0.5 ft) for the C103BS and EST-SED samples, respectively. Of the complete list of organics analyzed for only seven were had detections. These seven are; 2, 4-D, Acetone, Di-n-butylphthalate, Di-n-octylphthalate, Diethylphthalate, Methylene Chloride,

and bis(2-Ethylhexyl) phthalate. Of these organics, all but 2, 4-D are common laboratory contaminants. ANL-W will retain the contaminants for evaluation in the risk assessment.

**4.1.10.3 Radionuclides.** Gamma-emitting radionuclides were analyzed for in the 35 soil samples collected from the 1994 study with alpha and beta emitters analyzed for in two surface samples (4E and 16E) from the 1994 study. U-238 was the only radionuclide detected at a concentration greater than its 95%/95% upper tolerance limit on background concentrations (1.85 pCi/g) at a concentration of 2.7 pCi/g at location 4E.

**4.1.10.4 Extent of Contamination.** Using the information in the preceding 3 sections the nature and extent of contamination to be used in the risk assessment can be determined. The majority of the concentrations that exceed background concentrations (when available) are located in the southern portion of the ditch near the cooling tower. However, there are some concentrations greater than the upper limit of background for some metals in the northwestern part of the ditch (e.g., antimony, cyanide, manganese, selenium, and silver). In addition, concentrations of all metals except for one of the two analytical results for mercury (0.35 mg/kg) in Old Ditch D were below the upper tolerance limit of background concentrations. The relatively short section of Old Ditch D is eliminated as part of the extent of contamination since only once contaminant was detected and the arsenic and chromium and arsenic (known COC contaminants) concentrations are below the background levels. Also, its one mercury sample is much smaller in magnitude than the currently used portion of the ditch and (13.4 vs. 0.35 mg/kg). Therefore, the horizontal extent of contamination is the dimensions of both the eastern and western part of the MCTBD [1 to 4.6 m wide and 213 m long (3 to 15 ft wide and 700 ft long)]. Because the width of the ditch varies from 1 to 4.6 m (3 to 15 ft), an average width of 2 m (6 ft) will be used.

The majority of the contamination was detected in the top 15 cm (6 in.) of the ditch. Although there were some detections greater than the upper limit of background in some subsurface samples collected for manganese and silver, overall the majority of the contamination is confined in the top 15 cm (6 in.). Therefore, the vertical extent of contamination is assumed to be one-half the average depth to basalt 60 cm (2 ft).

#### **4.1.11 OU 9-04: ANL Interceptor Canal (ANL-09—Canal)**

This section summarizes the analytical results for soil samples collected at the Interceptor Canal. As discussed in Section 3.1.1.4.3, the same line was used to discharge industrial wastes to the Interceptor Canal as was used to discharge radioactive liquid wastes to the EBR-II Leach Pit. After each radioactive discharge to the Leach Pit, water was used to flush the pipe. However, this did not eliminate all contamination and subsequently, the Interceptor Canal was contaminated. Radioactively contaminated soil was detected in the interceptor canal in 1969 and subsequent radiation surveys in 1973 and 1975. Of the approximately 1,147 m<sup>3</sup> (1,500 yd<sup>3</sup>) of contaminated soil, 76.45 m<sup>3</sup> (100 yd<sup>3</sup>) were removed and the rest soil still remains at the site. Another radiation survey was conducted in 1993 that indicated elevated readings above background; therefore, in 1994, additional soil samples were collected from the Interceptor Canal.

Soil samples from the Interceptor Canal were analyzed for radionuclides; however, only soil samples collected in the southern portion of the canal near the inlet pipe were analyzed for metals. Section ANL-09—Canal of Appendix A shows the sampling location plan map, color intensity profile maps, scatter plots of the data, screening tables, statistics for COC by pathway, and combined data set for all samples collected from ANL-09—Canal. A small drilling rig was used with a split spoon sampler to collect soil samples at various depths from the same sampling location. This allowed ANL-W to determine the extent of subsurface migration of radionuclides. Surface soil samples [0–15 cm (0–6 in.)] and a subsurface soil sample [approximately 1 to 1.2 m (3 to 4 ft)] were collected at each location. In

addition, another soil sample was collected from approximately 1.5 to 1.8 m (5 to 6 ft) at three sample locations (#356, #368, and #378).

**4.1.11.1 Metals.** Soil samples located in the southern end of the canal were analyzed for metals. Of the 17 metals analyzed for (aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, cyanide, lead, manganese, mercury, nickel, selenium, silver, thallium, vanadium, and zinc), only arsenic, copper, lead, mercury, and silver are retained as COPCs from Table 3-13. Copper and lead are eliminated as COPCs because the calculated UCLs are less than the INEEL background concentration.

Scatter plots were prepared to illustrate the concentration of the metals based on depth and location relative to the inlet pipe. These scatter plots are presented in Section ANL-09—Canal of Appendix A. The 95%/95% upper tolerance limit on background concentrations, when available, is presented on each scatter plot to indicate which detections of the metals were detected at concentrations greater than the upper limit of background and will be evaluated in the risk assessment.

Arsenic was detected at several locations at concentrations greater than background (7.4 mg/kg) with concentrations ranging from 6.1 to 11.9 mg/kg. The highest concentration was detected in the first subsurface sample collected from location #368, with it decreasing to 10.9 in the subsequent sample collected at that location. Although the concentration of arsenic is higher than background at depth at this and other locations at the site, it should be noted that these concentrations are relatively close to background. Therefore, the vertical extent of contamination is assumed to be bound by the maximum sample collection depth.

Copper was detected above the upper tolerance limit in only 6% (1/17) samples that were collected at 34.8 mg/kg. This 34.8 mg/kg is less than the 99%/95% upper tolerance limit value for INEEL soils.

Lead was detected at concentrations greater than background (23.1 mg/kg) in surface soil samples at two sample locations (#378 and #368). These concentrations are 39.7 and 37.7 mg/kg, respectively.

Mercury was detected in six of the samples at concentrations ranging from 0.12 to 0.25 mg/kg. Four of the detections were at the detection limit of 0.12 mg/kg in sample locations #368, #372, and the two deeper samples collected from #378. The other two detections (0.25 and 0.33 mg/kg) were at locations #65 and #366 in the subsurface and surface sample, respectively. It should be noted that the mercury detection limits were greater than the background concentration of 0.074 pCi/g.

Silver was detected at sample location #368 at a concentration of 1.6 mg/kg in the surface soil sample [0 to 15 cm (0 to 6 in.)]. Silver was not detected in the sample collected at 0.9 to 1.1 m (3 to 3.5 ft) deep.

**4.1.11.2 Radionuclides.** Radionuclides were analyzed for in soil samples collected from the canal. Scatter plots were prepared to illustrate the horizontal extent of contamination and are presented in Section ANL-09—Canal of Appendix A. Because of a large number of sample locations, individual lines delineating each sample location are not shown on these plots. The 95%/95% upper tolerance limit on background concentrations, when available, is presented on each scatter plot to indicate which detections of the radionuclides were detected at concentrations greater than the upper limit of background and will be evaluated in the risk assessment.

Cobalt-60 was detected at eight of 69 sample locations in the canal at concentrations ranging from not detected to 0.25 pCi/g. The highest Co-60 concentration was detected in the southern end of the canal near the inlet pipe at sample location #412 [0 to 15 cm (0 to 6 in.)]. Other sample locations with detected

Co-60 concentrations are #77, #82, #125, #167, #249, #269, and #378. Although Co-60 concentrations at some sample locations increase with depth, the detected concentrations are relatively low (i.e., less than 0.25 pCi/g). Because Co-60 is not a naturally-occurring radionuclide, no background concentration has been established.

Cesium-134 was detected in one sample of the 69 it was analyzed for. This sample was collected at grid location 101 and was collected over the 0-15 cm (0-0.5 ft) depth range. There is no background level for Cs-134 and so any positive detection is considered to be above background.

Cesium-137 was detected at 43 of 69 samples in the canal at concentrations ranging from not detected to 18 pCi/g. The highest Cs-137 were also detected in the northern end of the canal at sample location #77 [0 to 15 cm (0 to 6 in.)]. The next two highest concentrations of Cs-137 were from sample locations #167 (13 pCi/g) and #412 (17 pCi/g), and as expected, these samples were also from the surface soils at these sample locations. Of the 21 samples with concentrations above the INEEL background, only one of these was collected at subsurface soil samples. This was collected at location 412 with a concentration of 1.9 pCi/g at a depth of 1 to 1.2 m (3 to 4 ft). The trend for the Cs-137 contamination was for the Cs-137 to be the highest in the surface sample and having decreasing contamination with depth.

**4.1.11.3 Extent of Contamination.** Using the information in the preceding two sections, the nature and extent of contamination to be used in the risk assessment can be determined. The majority of the concentrations of which exceed background concentrations (when available) are located in the southern portion of the canal near the inlet pipe. However, for the radionuclides, concentrations exceeding background (when available) were located throughout the canal. Therefore, for radionuclides, the horizontal extent of contamination is defined as the entire length of the canal [434 × 9 m (1,425 × 30 ft)]. For metals, the horizontal extent of contamination is assumed to be bound by the samples collected.

At the Interceptor Canal, the number of detections of Cs-137 in the subsurface soil sample decreased from 99% in the surface soil samples to only 69% of the subsurface samples. Only one subsurface soil sample contained Cs-137 above the INEEL background value. Therefore, the vertical extent of contamination will be assumed to be the maximum depth of sample collected with a concentration greater than background 1 to 1.2 m (3 to 4 ft).

#### **4.1.12 OU 9-04: ANL Interceptor Canal Mound (ANL-09—Mound)**

This section summarizes the analytical results for soil samples collected at the Interceptor Canal Mound area. As discussed in Section 3.1.1.4.3, the same line was used to discharge industrial wastes to the Interceptor Canal as was used to discharge radioactive liquid wastes to the EBR-II Leach Pit. After each radioactive discharge to the Leach Pit, water was used to flush the pipe. However, this did not eliminate all contamination and subsequently, the Interceptor Canal was contaminated. Radioactively contaminated soil was detected in the interceptor canal in 1969 and subsequent radiation surveys in 1973 and 1975. Approximately 2,064 m<sup>3</sup> (2,700 yd<sup>3</sup>) of soil identified as being contaminated in the original mound, of which 680 m<sup>3</sup> (890 yd<sup>3</sup>) were removed, and the remaining 1,384 m<sup>3</sup> (1,810 yd<sup>3</sup>) soil still remains in the mound. Another radiation survey was conducted in 1993, which indicated elevated readings above background; therefore, soil samples were collected from both the mound and below the mound (old canal bank).

Soil samples from the Interceptor Canal Mound were only analyzed for radionuclides. The reason for only sampling radionuclides is based on review of the operational process and agreement with regulators during the February 3, 1994 kickoff meeting. Samples collected in the canal bottom in 1994 from areas near the discharge pipes support the elimination of inorganics as COCs in the Mound. The

1994 canal samples show four inorganics (arsenic, lead, mercury and silver) as being retained because they are above background. Arsenic is below the ANL-W site specific background (Appendix K), lead is eliminated in two of the three pathways because the calculated UCL is below the INEEL background, silver does not have a background level and any detection exceeds background, and INEEL mercury levels are near detection limits. Section ANL-09—Mound of Appendix A shows the sampling location plan map, scatter plots of the data, screening tables, statistics for COC by pathway, and combined data set for all samples collected from ANL-09—Mound. Surface soil samples [0 to 15 cm (0 to 6 in.)] and a subsurface soil sample [approximately 1 to 1.2 m (3 to 4 ft.)] were collected at the ANL-09-Mound area. In addition, another subsurface soil sample was collected from approximately 1.5 to 1.8 m (5 to 6 ft.) at three sample locations (#356, #368, and #378). Subsurface soil samples were collected at a depth that corresponds to the bottom of the mound.

**4.1.12.1 Metals.** No metal samples were collected at the ANL-09-Mound area based on process knowledge of the COPCs.

**4.1.12.2 Radionuclides.** Radionuclides were analyzed for in soil samples collected from the excavated soil to the west of the canal (i.e., ANL-09-Mound). Scatter plots were prepared to illustrate the horizontal extent of contamination and are presented in Section ANL-09—Mound of Appendix A. Because of a large number of sample locations, individual lines delineating each sample location are not shown on these plots. The 95%/95% upper tolerance limit on background concentrations, when available, is presented on each scatter plot to indicate which detections of the radionuclides exceeded the 95%/95% values.

Six radionuclides were detected in soil samples collected from the mound as shown in Table 3-14. These radionuclides are Am-241, Cm-244, Co-60, Cs-137, Sr-90, and U-238. Of these radionuclides, Cm-244 and Co-60 do not have INEEL background concentrations and any positive detection is retained for inclusion in the risk assessment. Am-241 was detected in the surface soil sample at two locations (M3 and M19) at a concentration of 0.13 pCi/g at both locations. It should be noted that the detection limits are greater than the background concentration (0.019 pCi/g).

Curium-244 was detected in the surface soil sample at M3 at a concentration of 0.06 pCi/g. In addition, the detected concentration of U-238 (2.3 pCi/g) exceeded its background concentration (1.85 pCi/g) at this location. No subsurface soil samples were analyzed for these radionuclides.

Cobalt-60 was detected at 39% (11 of 28) of sample locations throughout the mound ranging from not detected to a maximum concentration of 0.37 pCi/g. Based on the scatter plot, there is no one area in the mound where Co-60 was detected at higher concentrations than other areas.

Cesium-137 was also detected at every sample location throughout the mound, with the highest detected concentration (52 pCi/g) at location M19. Cs-137 concentrations detected in the surface soil sample typically decreased one order of magnitude in the subsurface sample.

Strontium-90 was detected at three locations greater than background ranging from 2.1 to 5.8 pCi/g. These detected concentrations were from the surface soil sample and from locations M24, M27, and M28 in the southern portion of the ditch. No subsurface soil samples were analyzed for Sr-90. However, it is likely that the vertical distribution of Sr-90 follows the same pattern as for Cs-137, and should decrease with increased depth.

**4.1.12.3 Extent of Contamination.** Using the information in the preceding two sections, the nature and extent of contamination to be used in the risk assessment can be determined. The majority of the

radionuclides analyzed had concentrations exceeding background (when available) and were located throughout the mound. Therefore, for radionuclides, the horizontal extent of contamination is defined as the entire length of the mound [ $152 \times 6$  m ( $500 \times 20$  ft)].

At the mound, although some of the Cs-137 concentrations are greater than background at these depths, there is a significant decrease in concentrations (approximately one order of magnitude) between the concentration of Cs-137 in the surface sample and the sample collected at depth. The maximum detected Cs-137 concentration in the subsurface sample (5.9 pCi/g) is only a factor of five greater than background (1.28 pCi/g). Therefore, the vertical extent of contamination will be assumed to be the maximum depth of sample collection 1.2 m (4 ft).

#### **4.1.13 OU 9-04: Industrial Waste Lift Station Discharge Ditch (ANL-35)**

This section summarizes the analytical results for soil samples collected at the Industrial Waste Lift Station Discharge Ditch. As discussed in Section 3.1.1.4.4, this ditch was used to receive industrial waste water, primarily cooling water and photo processing wastes (e.g., photo developers, fixers, and stabilizers, and acids), but also including several retention tank overflows that may have contained ethanol, sodium hydroxide, and some radionuclides.

Soil samples were collected from this site on three separate occasions. Three soil samples were collected during the DOE Survey (DOE, 1989), 17 soil samples were collected in 1988 (Chen Northern 1989), and an additional 19 soil samples were collected in 1994 (ANL-W 1995). Section ANL-35 of Appendix A shows the sampling location plan map, color intensity profile maps, scatter plots of the data, screening tables, statistics for COC by pathway, and combined data set for all samples collected from ANL-35. The soil samples collected for the DOE survey were analyzed for metals, gamma-emitting radionuclides, tritium, Sr-90, gross alpha, gross beta, and VOCs. For the Chen Northern study, the soil samples were analyzed for metals, radionuclides, VOCs, semi-VOCs, pesticides, organo-phosphates, herbicides, and dioxin-furans, and the soil samples collected in 1994 were analyzed for metals and radionuclides.

Depths of collection for the soil samples collected in the three different studies varied. The sample collection depth for the DOE survey in 1988 is 0 to 0.6 m (0 to 2 ft), for the Chen Northern study it ranged from 0 to 0.6 m (0 to 2 ft) to 1.2 to 2.4 m (4 to 8 ft), and for the 1994 study the sample collection depths were 0 to 15 cm (0 to 6 in.) and 0.5 to 0.6 m (1.5 to 2 ft).

Surface water samples were collected in 1988. Analytical results for these samples are presented in Section 4.2.

**4.1.13.1 Metals.** Metals were analyzed for in all three studies. However, only two sample locations in the Chen-Northern study were analyzed for Appendix VIII metals. The same analytical methods were used for all the different studies except for beryllium and silver which are discussed below. It should be noted that when detection limits changed between the studies, they typically decreased from 1988 to 1994. Of the inorganics, 23 were retained as COPCs from Table 3-15. Eight metals (chloride, cyanide, fluoride, nitrate, phosphate, silver, strontium, and sulfate) are retained because there is no INEEL background and any positive detection of these inorganics are retained as COPCs. Also, eight inorganics (arsenic, barium, beryllium, cadmium, lead, manganese, nickel, and vanadium) are eliminated as COPCs in Appendix A because the calculated UCL for these inorganics is below the INEEL background concentrations.

Because metals and radionuclides were analyzed for in multiple years where different sample collection depths were used, scatter plots were developed to determine if the concentrations were similar between the different studies. These scatter plots are presented in Section ANL-35 of Appendix A. The 95%/95% upper tolerance limit on background concentrations is presented on each scatter plot to indicate which detections of the metals were detected at concentrations greater than background and will be evaluated in the risk assessment. In addition, discharge points into the ditch are indicated by vertical lines on the scatter plots. The eastern-most discharge point is the right boundary of the plots. Blanks in the scatter plots indicate that the soil sample was not analyzed for at that sample location. The results of this comparison indicate that although the sample collection depths vary, generally the samples can be combined to form one data set for the baseline risk assessment. The exception to this is beryllium.

Concentrations of beryllium collected in 1994 ranged from non detect to 1.1 mg/kg, with detection limits ranging from 0.32 to 0.55 mg/kg using furnace atomic absorption. Two soil samples were analyzed for beryllium in the Chen Northern study with concentrations of 5.8 and 5.5 mg/kg. These two soil samples were analyzed using inductively coupled plasma. Beryllium concentrations for the three soil samples collected from the DOE survey ranged from 1.5 to 2 mg/kg using furnace atomic absorption. At approximately the middle point of the ditch, soil samples were collected in each study from approximately the same location. These sample locations, concentrations and depth of collection are #36 (0.72 mg/kg), ND15BS (5.8 mg/kg), and grid 38 (1.7 mg/kg). Because of the variation in the sample results, because of the use of a more appropriate analytical method for the 1994 and DOE survey data, and because of the large number of samples collected for these two studies, data from these two studies will be used in the baseline risk assessment.

Arsenic was analyzed for in soil samples collected in 1994 and in the Chen-Northern study. Analytical results for seven of the 36 sample locations in both studies had concentrations greater than the upper limit of background for arsenic (7.4 mg/kg). The maximum detected soil concentration for arsenic is 12.1 mg/kg. This concentration was detected at location ND41CD near the first discharge point. Other locations that had relatively higher arsenic concentrations are at the eastern end of the ditch (ND41BS) and in the middle of the ditch (#41).

Barium was analyzed for in all these studies, and only one sample location at ANL-35 had a concentration of barium in the soil (647 mg/kg) greater than the upper limit of background (440 mg/kg). This location is #36 and is located in the middle of the ditch.

Four sample locations had cadmium concentrations greater than the upper limit of background (3.7 mg/kg). These locations are #36 (4.4 mg/kg), #65 (4.4 mg/kg), #65 (4.8 mg/kg), and #79 (3.9 mg/kg). The two samples collected from location #65 represent two depths [i.e., 0 to 15 cm (0 to 6 in.) and 15 to 30 cm (6 to 12 in.)]. Location #36 is located in the middle of the ditch, #65 is located just east of Harrison Road, and #79 is located just north of the cooling towers, also east of Harrison Road. Cadmium was analyzed for in all three studies.

The upper limit of background for chromium (50 mg/kg) was exceeded at 10 of 39 sample locations at ANL-35. The majority of these locations were sampled in the 1994 study. However, one soil sample collected from both the Chen-Northern study (1989) and the DOE survey (DOE 1989) exceeded background. These locations are ND15BS (124 mg/kg) and grid 18 (66 mg/kg), respectively. ND15BS is located in the middle of the ditch, and grid 18 is located at the western portion of the ditch. The two sampling locations in the 1994 study with the highest chromium concentrations are #65 (109 and 118 mg/kg) and #79 (90 mg/kg). The two samples collected from location #65 represent two depths [i.e., 0 to 15 cm (0 to 6 in.) and 15 to 30 cm (6 to 12 in.)].

Cobalt was analyzed for in both soil samples collected in 1994 and the DOE survey. One sample location had a detectable cobalt concentration greater than the upper limit of background (18 mg/kg). This sample location is #36 with a concentration of 27 mg/kg.

Concentrations of copper in soil exceed the upper limit of background (32 mg/kg) at 67% (16 of 24) sample locations in the ditch. The highest detection (479 mg/kg) was found at location #76 in the eastern portion of the ditch. Copper was analyzed for in all three studies.

The highest detection of cyanide was at location #65 at a concentration of 14.3 mg/kg. Cyanide was detected in six of the 21 samples analyzed for cyanide (i.e., the 1994 study and two sample locations from the Chen-Northern study). One cyanide concentration was "R" flagged and is not included in the baseline risk assessment.

Lead concentrations exceed the upper limit of background (23 mg/kg) in eight of the 39 samples analyzed. No samples collected from the DOE survey exceed background, and only two samples (ND03AS and ND40BS) from the Chen-Northern study exceed background (27.6 and 25.5 mg/kg, respectively). These samples are located at either end of the ditch. The highest lead concentration (47.2 mg/kg) was detected at #36 which is located in the middle of the ditch.

Manganese concentrations exceeded the upper limit of background (700 mg/kg) at two sample locations. These locations are #36 (1,200 mg/kg) and #76 (1,180 mg/kg). Manganese was not detected in any samples collected from the DOE survey, and it was not analyzed for in samples collected from the Chen-Northern study.

The highest detection of mercury was at ND15BS at a concentration of 1.3 mg/kg. The majority of the analytical results are greater than background in addition to the detection limits. The three detections lower than the upper limit of background (0.074 mg/kg) were from samples collected for the DOE survey. Mercury was analyzed for in all three studies.

Nickel was also analyzed for in all three studies and exceeded its upper limit of background concentration (55 mg/kg) at only one sample location (64.4 mg/kg) at #36.

Selenium was detected in two of 36 samples analyzed. These locations are #41 (0.78 mg/kg) and #42 (0.66 mg/kg). It should be noted that on the scatter plot, what appears to be a high detection of selenium at location ND03AS is actually a detection limit.

Silver was analyzed for in all three studies and was detected at 87% (33 of 39) of the sample locations with the highest detection (352 mg/kg) at #41. This sample location is located in the middle of the ditch.

Strontium was analyzed in two samples in ANL-35. It was positively detected in one sample with a concentration of 63 mg/kg.

Thallium was detected above the INEEL background concentration of 0.68 mg/kg in only one sample with a concentration of 0.7 mg/kg.

Vanadium exceeded the INEEL background concentration of 70 mg/kg in on one sample with a concentration of 71.6 mg/kg. Vanadium has been eliminated as a COPC for this site since the UCL is less than the INEEL background concentration.



Zinc exceeded its upper limit of background (220 mg/kg) at six of the 24 locations analyzed. The two highest detections are located at #36 (491 mg/kg) and #65 (444 mg/kg). Zinc was not detected in any location from the Chen-Northern or DOE survey.

In addition five inorganics chloride, fluoride, nitrate, phosphate and sulfate which are typical indicator of human impacts to the environment were also analyzed. These five inorganics do not have background data and are retained for assessment in the risk assessment. These were all detected in 100 percent of the samples with the exception of only three of five samples for sulfate.

**4.1.13.2 Radionuclides.** Radionuclides were analyzed at selected soil sample locations in the 1994 study and at all three sample locations for the DOE survey (DOE, 1989). Four radionuclides were retained from Table 3-15. They are Co-60, Cs-137, tritium, and U-238. Tritium and Co-60 are retained because no INEEL background concentration exists and any true detections are retained as COPCs. The only two radionuclides that exceed their background concentrations are Cs-137 and U-238. Cs-137 was detected above background (1.28 pCi/g) at #65 with concentrations of 2 pCi/g in the top 15 cm (6 in.) and 1.4 pCi/g from 0.5 to 0.6 m (1.5 to 2 ft). U-238 was slightly higher than background (1.85 pCi/g) at a concentration of 2.3 pCi/g at location #65 in the top 15 cm (6 in.).

Cs-137 was detected at concentrations less than the upper limit of background at all three DOE survey sample locations. Gross alpha and gross beta concentrations ranged from 3.6 to 4.0 pCi/g and 3.8 to 4.8 pCi/g, respectively. Gross alpha and beta measurements of soil are difficult and can lead to erroneous results, as the soil tends to self shield. Co-60 was detected at all three sample locations for the DOE survey at concentrations ranging from 0.003 to 0.035 pCi/g. These concentrations are less than the detection limit (0.06 pCi/g) for the samples collected in the 1994 study. Tritium was also detected in all three samples collected from the DOE survey. Tritium concentrations ranged from 0.262 to 0.719 pCi/g. Tritium measurements in soil is like wise filled with error as it tends to evaporate as water vapor. There is no background concentration available for either Co-60 or tritium.

**4.1.13.3 Organic Compounds.** Two soil samples from the Chen-Northern study (ND15BS and ND40BS) and all three samples from the DOE survey (DOE 1989) were analyzed for appendix VIII organic compounds. Organic compounds detected are 1,1,1-trichloroethane, 2-butanone, 2,4-D, acetone, acetonitrile, bis(2-ethylhexyl)phthalate, butylbenzylphthalate, di-n-butylphthalate, di-n-octyl-phthalate, chloroform, various isomers of dioxin-furans, methylene chloride, and toluene. Of these compounds, only 1,1,1-TCA and methylene chloride were detected in all five sample locations at concentrations ranging from 4 to 530 and 50 to 210 ug/kg, respectively. Acetone was detected at both locations sampled in the Chen-Northern study and two locations sampled in the DOE survey at concentrations ranging from 27 to 220 ug/kg.

Dioxin/furans and herbicides (e.g., 2,4-D) were analyzed for at the two samples collected for the Chen-Northern study. Three of the dioxin/furan isomers (i.e., HpCDD, OCDD, and OCDF) and 2,4-D were detected at both sample locations. The remaining dioxin/furan isomers (HpCDF, HxCDF, PeCDD, and TCDF) were detected at location ND15BS. Acetonitrile, butylbenzylphthalate, and di-n-octylphthalate were only detected at ND40BS, and bis(2-ethylhexyl)phthalate and di-n-butylphthalate were only detected at the two locations sampled in the Chen-Northern study. 2-butanone was detected at all three locations sampled from the DOE survey, toluene was detected in two of the samples collected from the DOE survey and one location from the Chen-Northern study (ND40BS), and chloroform was detected at one location from the DOE survey.

**4.1.13.4 Extent of Contamination.** Using the information in the preceding three sections, the nature and extent of contamination to be used in the risk assessment can be determined. The majority of the concentrations of metals, radionuclides, and organic compounds that exceed background concentrations

(when available) are located in the middle or eastern portion of the ditch. However, high concentrations of arsenic, copper, chromium, mercury, lead, silver, and zinc were detected in sample locations grid 18, ND03, 15, 18, and 19. Therefore, the horizontal extent of contamination is defined as the entire length of the ditch.

The vertical extent of contamination will be based on the depth of basalt across the entire length of the ditch. This depth varies from 0.06 to 0.8 m (0.2 to 2.5 ft) with an average depth of 0.3 m (1.0 ft). Therefore, the dimensions of ANL-35 are  $4.6 \times 152 \times 0.3$  m ( $15 \times 500 \times 1$  ft).

#### 4.1.14 OU 9-04: Cooling Tower Riser Pits (ANL-53—Riser Pits)

The four cooling tower riser pits received cooling tower water that was drained during long duration EBR-II reactor shutdown periods in the winter to prevent the pipes from breaking if the water were to freeze. During short-duration EBR-II reactor shutdown periods, the middle two riser pits were drained and the outer two risers were used to circulate water from EBR-II to the cooling tower to keep the water in the basin from freezing. The cooling tower water in the riser pipe from ground surface to the bottom of the riser pits [3.5 m (11.5 ft) bgs] were drained by opening a small valve in the line. This water then leached into the ground directly below each of the four riser pits. The cooling water was treated with chromate-based corrosion inhibitors until 1980. Therefore, chromium is expected to be present in the riser pits and the areas downgradient of the discharge lines. Based on literature from the manufacturer, the chromium is almost instantaneously reduced from the hexavalent to the trivalent state. In addition, based on process knowledge, arsenic, lead, and mercury may also be present at this site.

Section ANL-53—Riser Pits of Appendix A shows the sampling location plan map, scatter plots of the data, screening tables, statistics for COC by pathway, and combined data set for all samples collected from the riser pits. Two soil samples were collected from each of the riser pits. These samples were collected from the floor of the pits and then again at a depth of either 22 cm (9 in.) or 38 cm (15 in.) below grade. The floor of the riser pits are located approximately 3.5 m (11.5 ft.) below ground surface.

Soil samples collected from the cooling tower riser pits were analyzed for four metals based on process knowledge (i.e., this site only received primarily cooling water). These metals are arsenic, hexavalent and trivalent chromium, lead, and mercury.

**4.1.14.1 Metals.** Scatter plots were prepared for this site and are presented in Section ANL-53—Risers Pits of Appendix A. All soil samples collected from the riser pits exceeded background. In comparison of the surface sample to the subsurface sample at each of the riser pits the trend of decreasing arsenic concentration with increasing depth is noted (79-19, 52-14, 51-43, and 73-15 mg/kg for riser pits 1 through 4 respectively).

No hexavalent chromium was detected in any of the soil samples. All chromium concentrations presented represent trivalent chromium. Chromium concentrations in the soil samples from six of the eight locations in the riser pits were greater than background (50 mg/kg) ranging from 29 to 1,727 mg/kg and these concentrations decreased with increased depth. The two locations with chromium concentrations less than background were from the sample collected at 22 cm (9 in.) and 38 cm (15 in.) below grade.

The same pattern of contamination was observed for lead. Lead concentrations in the riser pits ranged from 16 to 4,725 mg/kg.

Mercury was detected at concentrations above background in six of the eight samples collected from the riser pits ranging from 0.17 to 0.78 mg/kg. In the riser pits, the mercury concentrations tended to decrease with increased depth.

**4.1.14.2 Extent of Contamination.** The total horizontal extent of contamination is defined as the area encompassing the riser pits with aerial dimensions of 1.2 by 4.8 m (4 by 16 ft). The vertical extent of contamination is not well defined. Concentrations of the metals in riser pits 2 and 3 are not below background concentrations in each subsurface sample. The high concentrations in the soils in riser pits 1 and 4 are probably attributable to more water being discharged to these two riser pits. Risers 1 and 4 have the capability to re-circulate water so less water, would have been discharged to the riser pits (ANL-W 1993).

During the installation of the cooling tower, the basalt between 1 to 2 m (3 to 6 ft) bgs had to be removed. The basalt was removed to a depth of 3 m (10 ft) below natural grade. The soil around the cooling tower basin and riser pits has been backfilled to about 1 m (3 ft) above natural grade. The depth of the soil between the bottom of the riser pits and the basalt varies from 22 to 38 cm (9 to 15 in.) depending on the individual riser pit. Therefore no additional deeper soil samples could be collected to better define the vertical extent of contamination. Therefore, the vertical extent of contamination is assumed to be the maximum sample collection depth (i.e., the depth of soil between the bottom of the riser pit and basalt).

#### **4.1.15 OU 9-04: Cooling Tower Riser Pits North Discharge (ANL-53—North Discharge)**

The four cooling tower riser pits received cooling tower water that was drained during long duration EBR-II reactor shutdown periods in the winter to prevent the pipes from breaking if the water were to freeze. During short duration EBR-II reactor shutdown periods, the middle two riser pits were drained and the outer two risers were used to circulate water from EBR-II to the cooling tower to keep the water in the basin from freezing. Two discharge lines were used to drain the water from the top of the riser to ground level. One discharge line on the north side of the cooling tower drained the riser pits 1 and 2, and the other discharge line on the south side drained riser pits 3 and 4 as shown in Section ANL-53—North Discharge of Appendix A. The cooling water was treated with chromate-based corrosion inhibitors until 1980. Therefore, chromium is expected to be present downgradient of the discharge lines. Based on literature from the manufacturer, the chromium is almost instantaneously reduced from the hexavalent to the trivalent state. In addition, based on process knowledge, arsenic, lead, and mercury may also be present at this site.

Three soil samples were collected from the north discharge pipe. Section ANL-35—North Discharge of Appendix A shows the sampling location plan map, scatter plots of the data, screening tables, statistics for COC by pathway, and combined data set for all samples collected from north discharge area. Surface soil samples were collected from one surface soil sample [0 to 15 cm (0 to 6 in.)] and one deep soil sample [15 to 20 cm (6 to 8 in.)] below the discharge line and one soil sample was collected at the sample located 3 m (10 ft) north of the pipe outlet 20 to 25 cm (8 to 10 in.) below grade. Soil samples were analyzed for four metals based on process knowledge (i.e., this site only received primarily cooling water). These metals are arsenic, hexavalent and trivalent chromium, lead, and mercury.

**4.1.15.1 Metals.** Scatter plots were prepared for this site and are presented in Section ANL-35—North Discharge of Appendix A. Arsenic concentrations were below background (7.4 mg/kg) from all soil samples collected from the north discharge ditch.

No hexavalent chromium was detected in any of the soil samples. All chromium concentrations presented represent trivalent chromium. Chromium exceeded background at two locations from the north discharge pipe ranging from 56 to 59 mg/kg. The two locations where chromium exceeded background at the north discharge pipe were from sample location N-1.

The same pattern of contamination was observed for lead. The North Discharge concentrations ranged from 19.9 to 43.1 mg/kg.

Mercury was detected from the deeper sample at one location each in the area of the north discharge pipes at concentrations of 0.4 mg/kg. The background concentration for mercury is 0.074 mg/kg with the 99%/95% upper tolerance limit for mercury being 0.092 mg/kg.

**4.1.15.2 Extent of Contamination.** The total horizontal extent of contamination is defined as the area encompassing the north discharge pipes with aerial dimensions of 1.8 × 3 m (6 × 10 ft). The vertical extent of contamination is not well defined.

#### **4.1.16 OU 9-04: Cooling Tower Riser Pits South Discharge (ANL-53—South Discharge)**

The four cooling tower riser pits received cooling tower water that was drained during long-duration EBR-II reactor shutdown periods in the winter to prevent the pipes from breaking if the water were to freeze. During short-duration EBR-II reactor shutdown periods, the middle two riser pits were drained and the outer two risers were used to circulate water from EBR-II to the cooling tower to keep the water in the basin from freezing. Two discharge lines were used to drain the water from the top of the riser to ground level. One discharge line on the north side of the cooling tower drained the riser pits 1 and 2, and the other discharge line on the south side drained riser pits 3 and 4. The cooling water was treated with chromate-based corrosion inhibitors until 1980. Therefore, chromium is expected to be present in the riser pits and the areas downgradient of the discharge lines. Based on literature from the manufacturer, the chromium is almost instantaneously reduced from the hexavalent to the trivalent state. In addition, based on process knowledge, arsenic, lead, and mercury may also be present at this site.

Section ANL-53—South Discharge of Appendix A shows the sampling location plan map, scatter plots of the data, screening tables, statistics for COC by pathway, and combined data set for all samples collected from the South Discharge. Five soil samples were collected from the south discharge pipe. Sample locations are presented in Section ANL-53—South Discharge of Appendix A. Surface soil samples were collected from each of four locations from the southern discharge pipe at a depth of 0 to 15 cm (0 to 6 in.) with a second sample collected from approximately 20 to 25 cm (8 to 10 in.). Soil samples collected were analyzed for four metals based on process knowledge (i.e., this site only received primarily cooling water). These metals are arsenic, hexavalent and trivalent chromium, lead, and mercury. The hexavalent chromium was evaluated by first using extract procedure 1310 then analyzing using SW-846 method 7196A.

**4.1.16.1 Metals.** Scatter plots were prepared for this site and are presented in Section ANL-53-South Discharge of Appendix A. Arsenic concentrations were slightly above background in the surface soil sample at S-3 (7.7 mg/kg) at the south ditch.

No hexavalent chromium was detected in any of the soil samples. All chromium concentrations presented represent trivalent chromium. Chromium exceeded background one surface sample from the south discharge pipe at a concentration of 56 mg/kg.

Lead concentrations did not exceed background (23 mg/kg) at any location in the area of the south discharge pipe.

Mercury was detected from the deeper sample at one location in the south discharge at a concentration of 0.086 mg/kg. The background concentration for mercury is 0.074 mg/kg with the 99%/95% upper tolerance limit for mercury being 0.092 mg/kg. Therefore, it is possible that this one detection of mercury in the south discharge pipe area is still within the range of background.

**4.1.16.2 Extent of Contamination.** The total horizontal extent of contamination is defined as the area encompassing the riser pits and the discharge pipes with aerial dimensions of  $1.8 \times 3$  m ( $6 \times 10$  ft). The vertical extent of contamination is not well defined.

## **4.2 Surface Water Nature and Extent of Contamination**

Based on the surface water sampling results presented in Tables 3-20 and 3-21, surface water contamination is known to exist at ANL-W. However, these surface water bodies at ANL-W are not natural features but, rather, the result of intermittent land application of discharged effluents associated with laboratory and other ongoing processes at the site. These discharges are not required to meet any specific water quality standards as part of their disposal. Since the land application of liquid effluent is intermittent and not expected to result in usable bodies of water, these man-made surface water features are not considered in the BRA as a separate exposure pathway. However, infiltrating liquid effluent from land applications does have the potential to impact the groundwater exposure pathway.

Additionally, precipitation has the potential to concentrate in the various ditches, the Interceptor Canal, and IWP and to contribute further migration of contaminants to the groundwater pathway. The HELP model (EPA 1994) was used to prepare estimates of runoff associated with this site. The inclusion of runoff in the predictive groundwater transport model is discussed in further detail in the groundwater transport parameter section of this report (Section 5.6).

The examination of potential impact to groundwater that results from the land application of surface water discharges is initially discussed in the surface water contaminant screening section of this report (Section 3.3). That section presents the sampling results that are used to verify that the discharge approval process at ANL-W is functioning properly. Liquid effluent in The North Ditch flowed at a maximum rate of approximately 30 gpm during EBR-II reactor operations. Currently, only occasional discharges to the North Ditch occur and tend to range from 5-15 gpm with an average of about 9 gpm (Martin 1996).

Likewise, the makeup of constituents in the water contained in the IWP has undoubtedly changed considerably during the history of the IWP use. The IWP has received a variety of wastewater from various ditches. Due to current low flow rates, most discharge water does not reach the IWP before infiltrating the unlined feed ditches. Tables 3-20 and 3-21 identify the detected contaminants in the IWP and North Ditch wastewater. These indicate a more contaminants were detected in the IWP than in the North Ditch. This is probably due to other ditches also discharging to the IWP.

## **4.3 Perched Water Nature and Extent of Contamination**

Perched water at ANL-W rarely exists and then only as partially saturated zones above discontinuous interbeds, dense basalt interiors, or other low permeability zones within the basalt's. They form as the result of natural precipitation infiltration and liquid discharges that infiltrate through ditches

and the IWP. Perched water is not considered in this analysis as a separate exposure pathway. Since contaminated water in the vadose zone likely results from land application of discharged effluent, using both the vadose water sampling results and the surface water sampling results to estimate additional quantities of contaminants (beyond what has already been estimated from soil sampling results) would incorrectly overestimate the total inventories.

Additionally, the lateral and vertical extent of any perched water beneath ANL-W is not well known, if at all. It is therefore not practical to estimate the amount of contaminated perched water that could result in additional impact to the groundwater. As a result, the perched water sampling results presented in Table 3-22 are not used here to determine any perched water impacts through the groundwater exposure pathway.

#### **4.4 Nature and Extent of Groundwater Contamination**

The contaminants of concern initially identified for the groundwater exposure pathway, are based on existing groundwater samples. These, are presented Table 4-1 which also identifies the well from which the maximum detected concentrations were sampled and when the sampling occurred. The sampled wells are shown in Figure 3-3. Important information regarding the ANL-W aquifer monitoring and production wells shown in Figure 3-3 is given in Table 4-2. This table includes screened well intervals and diameters, sampling depths, and positions of intercepted interbeds, all of which contributes to better understanding of where water enters a sampled well, where the nearby interbeds are that may be capable of transmitting contaminants, and where the reported groundwater samples of Table 4-1 were collected relative to the possible routes of contaminant migration.

Figures 4-1 and 4-2 show the local and regional groundwater flow direction based on contouring of water levels measured from Snake River Plain aquifer wells. The figures indicate a east-northeast to west-southwest general direction of groundwater flow. This indicates that that the observation well M-12 is the most upgradient of the set of six wells listed in Table 4-2, relative to the general groundwater flow.

It is important to note that six of the eleven contaminants of concern listed in Table 4-1 had maximum detected concentrations in the upgradient monitoring well M-12, which is also outside of the administrative boundary of ANL-W. Four of the other contaminants of concern, including Sr-90, were detected at maximum concentrations in the monitoring well M-13, which is downgradient of the IWP. The maximum detected concentration for arsenic was found in the production well, EBR-II #2, which is centrally located at the site.

From the well locations shown in Figure 3-3, a rough triangle can be visualized in which well M-12 is at an upgradient corner and M-11 and M-13 are at two opposite downgradient corners. The USGS observation well Site-16 and the production wells EBR-II #1 and EBR-II #2 falls near or within this triangle. Such a configuration relative to the groundwater flow direction should be noticeable when examining the results of the samples collected from all of these wells. The well completion data in Table 4-2 and the contaminant concentration data of Tables 4-4, 4-5, and 4-6 are presented in columns left to right that roughly reflect the upgradient to downgradient locations of these wells. A major problem in assessing the nature and extent of groundwater contamination in the vicinity of ANL-W, however, is the paucity of recent groundwater quality data. The assessment presented in this report is based on approximately a year and half worth of groundwater data, collected from April, 1994 to October, 1995. This is the extent of available recent Level A validated data. No groundwater samples were collected in 1996. The analysis presented here is supplemented with validated data from a single sampling event from 1991 the monitoring well M-11, downgradient of the EBR-II Leach Pit.

Also supporting the assessment are data collected by the U.S. Geological Survey from a variety of wells near or at ANL-W that are monitored at least semi-annually by the USGS. These include the Arbor Test well to the southeast of ANL-W and USGS-100, located downgradient to the southwest of the site. The data in this set were not collected for the same monitoring objectives and were validated under different procedures. As a result, this supplemental data set are not directly comparable to the Level A validated set; however, they are presented here where necessary to qualitatively support the discussion.

Though the data analyzed here are limited, it should be noted that groundwater monitoring activities at ANL-W are ongoing and will continue at least semi-annually for the five years that this document is administratively effective. At that point, approximately two to three times the current available groundwater data will have been collected. Tables 4-4, 4-5, and 4-6 present the entire set of detected concentrations from Level A validated water quality sample results for organics, inorganics, and radionuclides, respectively. The list of analytes sampled at ANL-W include the 40 CFR 264 Appendix IX analysis for water along with INEEL site specific parameters including gross alpha, gross beta, and tritium, TDS, TOC, TOX, pH, total alkalinity, arsenic bicarbonate, cadmium, chloride, chromium, iodine, lead, magnesium, nitrate, potassium, silver, sodium, sulfate, thallium, zinc, 1,2 Dichloroethane, 1,1 Dichloroethylene, Methylene chloride, Tetrachloroethylene, 1,1,2 Trichloroethane, and Trichloroethylene. The tables are arranged to present data from upgradient to downgradient wells (left to right columns) as well as chronologically for each contaminant and each well (from top to bottom).

**Table 4-1.** Contaminants of concern detected in groundwater at ANL-W.

| Compound                   | Maximum detected concentration | Units | Sampled well | Date of sample | Relative location of well |
|----------------------------|--------------------------------|-------|--------------|----------------|---------------------------|
| bis(2-Ethylhexyl)phthalate | 370.                           | ug/L  | M-12         | 18-May-94      | upgradient                |
| Antimony                   | 105                            | ug/L  | M-13         | 25-Oct-95      | downgradient              |
| Arsenic                    | 3.8                            | ug/L  | EBR-II #2    | 19-May-94      | central                   |
| Cadmium                    | 6.2                            | ug/L  | M-12         | 12-Apr-94      | upgradient                |
| Nitrates                   | 7,340                          | ug/L  | M-13         | 25-Oct-95      | downgradient              |
| Tin                        | 2,640                          | ug/L  | M-13         | 25-Oct-95      | downgradient              |
| Am-241                     | 0.53 +/- 0.1                   | pCi/L | M-12         | 31-Jul-95      | upgradient                |
| Np-237                     | 7.1 +/- 0.6                    | pCi/L | M-12         | 20-Mar-95      | upgradient                |
| Sr-90                      | 1,330 +/- 6                    | pCi/L | M-13         | 25-Oct-95      | downgradient              |
| U-234                      | 1.5 +/- 0.4                    | pCi/L | M-12         | 20-Mar-95      | upgradient                |
| U-238                      | 1.9 +/- 0.4                    | pCi/L | M-12         | 25-Oct-95      | upgradient                |

The following is a discussion of each identified contaminant of concern. Those contaminants that failed a RBC screening criteria are compared to MCLs, if available. Each contaminant is examined relative to available background SRPA concentrations. Background was not used to screen potential contaminants in the groundwater contaminant screening section of this document (Section 3.5) because background concentrations are not well established for groundwater in the vicinity of ANL-W. Spatial and time-

dependent trends are discussed along with any supplemental data analysis and analysis of data qualifiers attached to the contaminants of concern.

The radionuclide contaminants of concern exceed their respective RBCs mostly in the upgradient well M-12; however, detections exceeding RBCs for Np-237, Sr-90, U-234, and U-238 were also detected in well M-13, downgradient of the IWP. Uranium concentrations in well M-13 barely exceed the RBC of 1.0 ug/L (U-234) and 0.79 (U-238). Note also that the data for Sr-90 is very anomalous and that the exceeding detections were sampled on the same date. Ongoing sample collection from both the upgradient and downgradient wells near ANL-W will be conducted semiannually in accordance to the ANL-W Groundwater Monitoring Plan. These sample results will be added to the existing data set and trend analysis will be conducted to better define why upgradient well M-12 has radionuclide contamination. Finally, note that many of the exceeding concentrations in Table 4-3 are either estimated values (quality flag J) or were detected in blank samples (quality flag B) as well.

Table 4-6 presents a collection of contaminant background concentration values for groundwater within the vicinity of ANL-W. The sources for these values are studies performed on the SRPA by the U.S. Geological Survey.

**Table 4-2.** General completion data for aquifer wells near or at ANL-W.

| Well  | M-12    | Site-16 | EBR-II #1 | EBR-II #2 | M-11    | M-13    |
|---|---------|---------|-----------|-----------|---------|---------|
| Screen dia. (inches)                                | 7-7/8   | 8       | 18        | 18        | 8       | 8       |
| Screen interval (ft)                                | 690-715 | 685-760 | 750-850   | 650-750   | 610-650 | 630-655 |
| Pump depth (ft)                                     | 715     | NA      | 725       | 725       | 654     | 665     |
| Water table ht (1996) (ft above MSL)                | 4,487.5 | 4,487.1 | 4,486.8   | 4,486.8   | 4,486.4 | 4,486.1 |
| Land surface elevation (ft above MSL)               | 5,132.8 | 5,121.7 | 5,121.7   | 5,121.7   | 5,118.7 | 5,120.4 |
| Depth to water table (1996) (ft)                    | 645.3   | 634.6   | 634.9     | 634.9     | 632.3   | 634.3   |
| Interbeds and flow breaks near water table (ft bls) | 528-545 | 540-550 | 565-580   | 546-552   | 580-581 | 545-550 |
|   | 565-572 | 590-594 | 580-600   | 580-585   | 593-608 | 565-570 |
|   | 602-608 | 633-660 | 634-640   | 604-606   | 602-604 | 617-635 |
|   | 615-620 | —       | —         | 653-657   | —       | —       |
|   | 647-650 | —       | —         | —         | —       | —       |

MSL is mean sea level (National Geodetic Vertical Mean of 1929).  
ft bls is feet below land surface.



**Table 4-3.** Listing by well of detected concentrations of organic contaminants of concern.

| Compound                       | RBC or MCL<br>(ug/L or pCi/L) | Well concentrations (ug/L or pCi/L) |           |           |      |      | Date<br>sampled |
|--------------------------------|-------------------------------|-------------------------------------|-----------|-----------|------|------|-----------------|
|                                |                               | M-12                                | EBR-II #1 | EBR-II #2 | M-13 | M-11 |                 |
| bis(2-Ethylhexyl)<br>phthalate | 4.8                           | 370                                 |           |           |      |      | 16-May-95       |
|                                |                               | 37                                  |           |           |      |      | 31-Jul-95       |
|                                |                               | 57 B                                |           |           |      |      | 25-Oct-95       |
|                                |                               |                                     | 73        |           |      |      | 10-May-95       |
|                                |                               |                                     |           | 5 J       |      |      | 18-May-94       |
|                                |                               |                                     |           | 51        |      |      | 9-May-95        |
|                                |                               |                                     |           |           | 270  |      | 16-May-95       |
|                                |                               |                                     |           |           | 40   |      | 31-Jul-95       |
|                                |                               |                                     |           |           | 29 B |      | 25-Oct-95       |
|                                |                               |                                     |           |           |      | 71   | 9-May-95        |

B Analyte also found in associated blank.  
J Estimated quantity.

**Table 4-4.** Listing by well of detected concentrations of inorganic contaminants of concern.

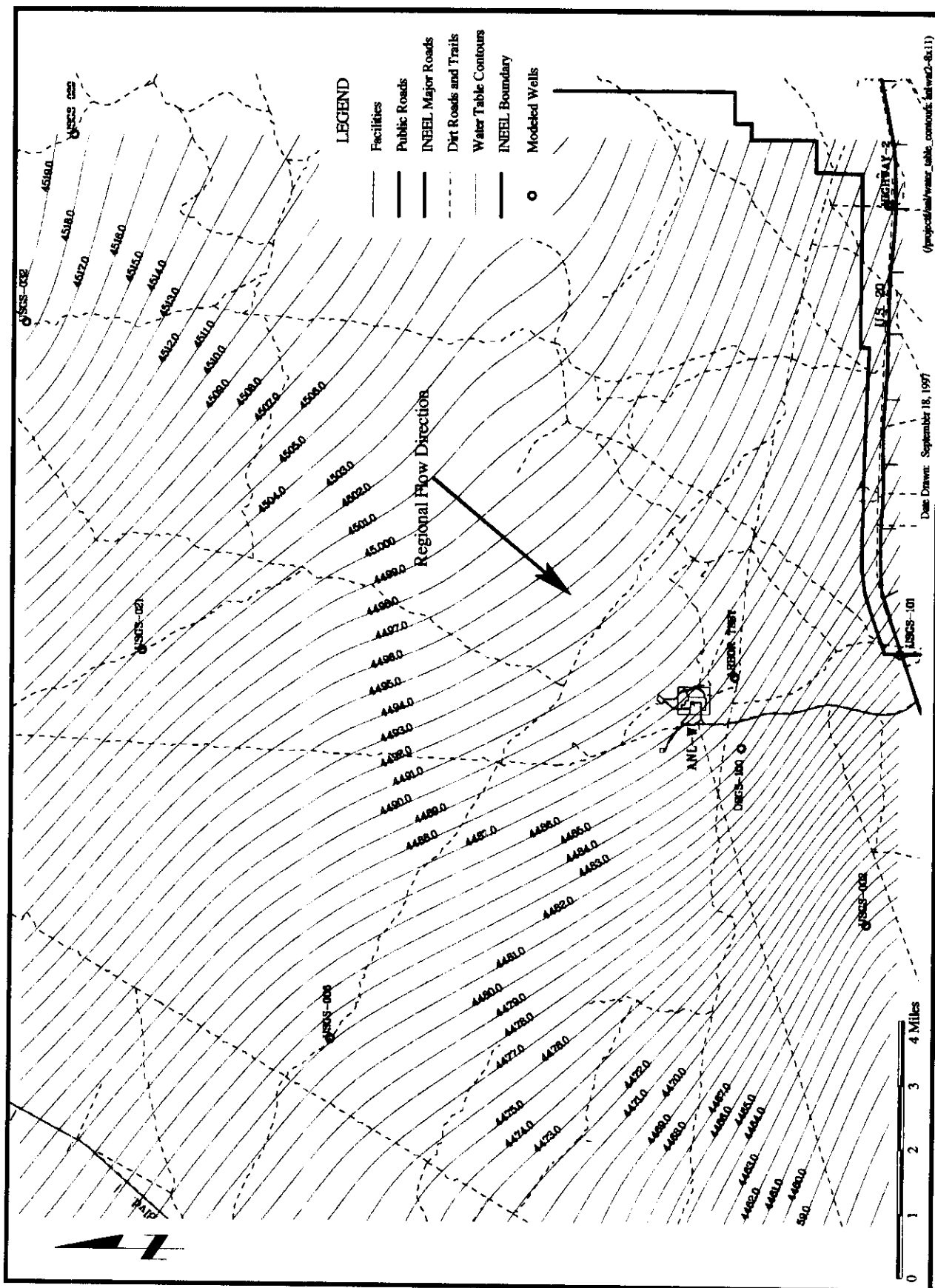
| Compound | RBC or MCL<br>(ug/L or pCi/L) | Well concentrations (ug/L or pCi/L) |           |           |         |       | Date<br>sampled |
|----------|-------------------------------|-------------------------------------|-----------|-----------|---------|-------|-----------------|
|          |                               | M-12                                | EBR-II #1 | EBR-II #2 | M-13    | M-11  |                 |
| Antimony | 1.5                           | 27.4 B                              |           |           |         |       | 20-Mar-95       |
|          |                               |                                     |           |           | 105     |       | 25-Oct-95       |
| Arsenic  | 1.1                           | 1.7 B                               |           |           |         |       | 20-Mar-95       |
|          |                               | 1.9 B                               |           |           |         |       | 25-Oct-95       |
|          |                               |                                     | 2.9       |           |         |       | 10-May-95       |
|          |                               |                                     | 2.5       |           |         |       | 29-Aug-95       |
|          |                               |                                     |           | 3.8 B     |         |       | 19-May-94       |
|          |                               |                                     |           | 2.5       |         |       | 9-May-95        |
|          |                               |                                     |           |           | 2.1 B   |       | 20-Mar-95       |
|          |                               |                                     |           |           | 3.6 N   |       | 25-Oct-95       |
|          |                               |                                     |           |           |         | 2.7   | 9-May-95        |
| Cadmium  | 1.8                           | 6.2                                 |           |           |         |       | 12-Apr-94       |
|          |                               |                                     |           |           |         | 2.9 B | 13-Apr-94       |
| Nitrate  | 5.8E+03                       | 1,400                               |           |           |         |       | 16-May-95       |
|          |                               | 5,510                               |           |           |         |       | 31-Jul-95       |
|          |                               | 6,130                               |           |           |         |       | 25-Oct-95       |
|          |                               |                                     | 6,180     |           |         |       | 29-Aug-95       |
|          |                               |                                     |           | 6,580     |         |       | 28-Aug-95       |
|          |                               |                                     |           |           | 1,600   |       | 16-May-95       |
|          |                               |                                     |           |           | 6,240   |       | 31-Jul-95       |
|          |                               |                                     |           |           | 7,340   |       | 25-Oct-95       |
|          |                               |                                     |           |           |         | 6,520 | 29-Aug-95       |
| Tin      | 2.2E+03                       |                                     |           |           | 2,640 P |       | 25-Oct-95       |

B Detected at concentration > instrument detection limit < contract required detection limit.

J Indicates value is estimated.

P Indicates problem with gas chromatography.

N Indicates spiked sample recovery not within control limits.



**Figure 4-1.** 1996 ANL-W Regional Water Table Contours.

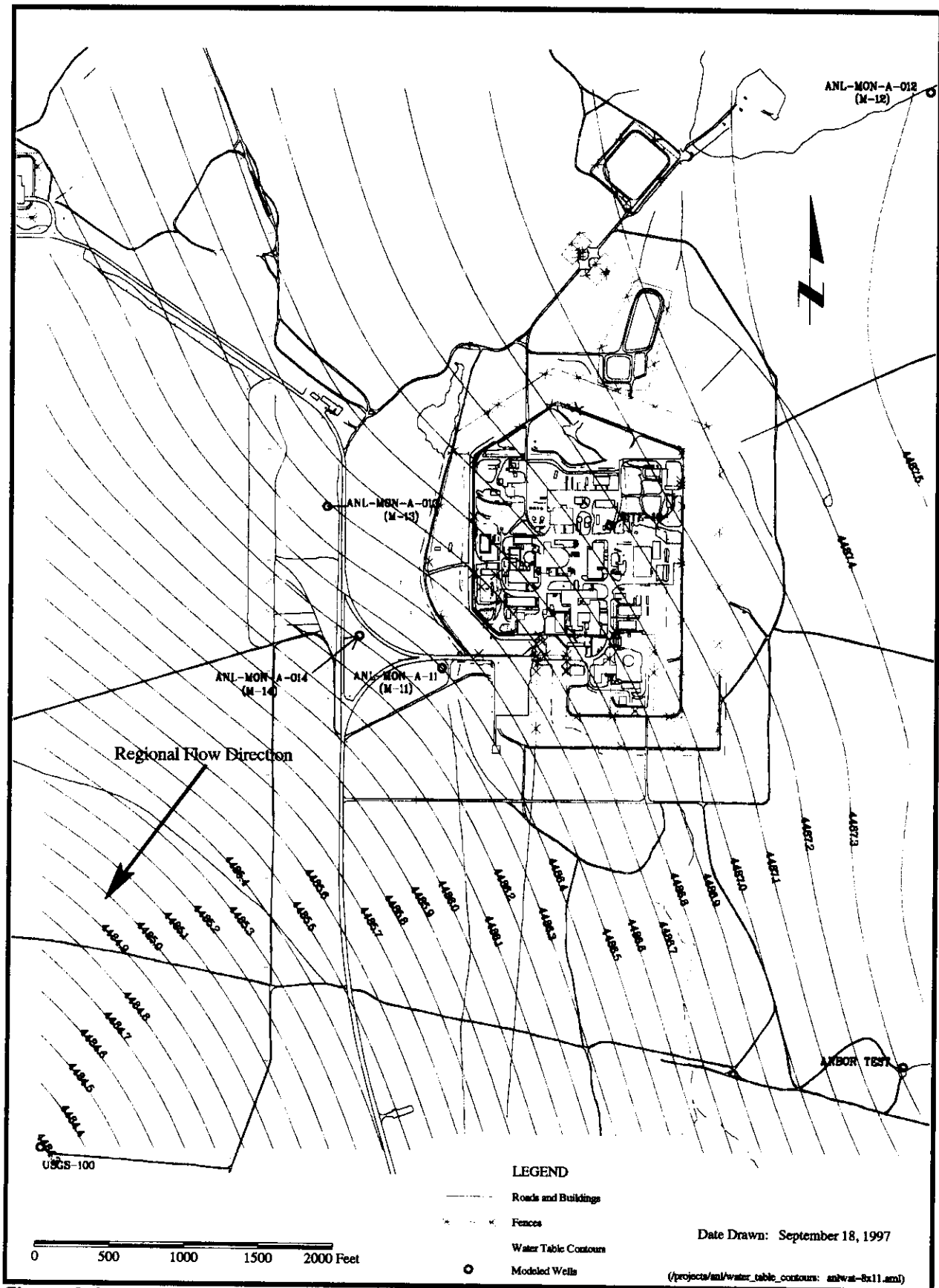


Figure 4-2. 1996 ANL-W Water Table Contours.

**Table 4-5. Listing by well of detected concentrations of radionuclide contaminants of concern.**

| Well concentrations (ug/L or pCi/L) |                                  |                  |           |           |                 |      |   |
|-------------------------------------|----------------------------------|------------------|-----------|-----------|-----------------|------|---|
| Compound                            | RBC or MCL<br>(ug/L or<br>pCi/L) | M-12             | EBR-II #1 | EBR-II #2 | M-13            | M-11 | Radionuclide<br>Uncertainty<br>(pCi/L) Date sampled |
| Am-241                              | 0.15                             | U                |           |           |                 |      | 12-Apr-94   |
|                                     |                                  | 0.37 J $\pm$ 0.1 |           |           | U               |      | 0.1 20-Mar-95                                       |
|                                     |                                  | U                |           |           | 0.15 $\pm$ 0.05 |      | 0.05 16-May-95                                      |
|                                     |                                  | 0.53 $\pm$ 0.1   |           |           | 0.2 $\pm$ 0.08  |      | 0.1, 0.08 31-Jul-95                                 |
|                                     |                                  | U                |           |           | U               |      | 25-Oct-95   |
| Np-237                              | 0.22                             | U                |           |           |                 |      | 12-Apr-94   |
|                                     |                                  | 7.1 $\pm$ 0.6    |           |           |                 |      | 0.6 20-Mar-95                                       |
|                                     |                                  | 2.8 $\pm$ 0.2    |           |           |                 |      | 0.2 16-May-95                                       |
|                                     |                                  | 0.4 $\pm$ 0.2    |           |           |                 |      | 0.2 31-Jul-95                                       |
|                                     |                                  | 2.3 $\pm$ 0.2    |           |           |                 |      | 0.2 25-Oct-95                                       |
|                                     |                                  |                  |           |           | 3.9 $\pm$ 0.5   |      | 0.5 20-Mar-95                                       |
|                                     |                                  |                  |           |           | 2.5 $\pm$ 0.2   |      | 0.2 16-May-95                                       |
|                                     |                                  |                  |           |           | 0 $\pm$ 0.1     |      | 0.1 31-Jul-95                                       |
| Sr-90                               | 0.85                             |                  |           |           | 0.3 $\pm$ 0.1   |      | 0.1 25-Oct-95                                       |
|                                     |                                  | U                |           |           |                 |      | 12-Apr-94   |
|                                     |                                  |                  |           |           | U               |      | 20-Mar-95   |
|                                     |                                  |                  |           |           | U               |      | 16-May-95   |
|                                     |                                  | 0.7 $\pm$ 0.3    |           |           | 0.1 $\pm$ 0.3   |      | 0.3 31-Jul-95                                       |
| U-234                               | 1.0                              | 1320 J $\pm$ 6   |           |           | 1,330 J $\pm$ 6 |      | 6 25-Oct-95   |
|                                     |                                  | 0.7 $\pm$ 0.3    |           |           |                 |      | 0.3 12-Apr-94                                       |
|                                     |                                  | 1.5 $\pm$ 0.4    |           |           | 1 $\pm$ 0.3     |      | 0.4, 0.3 20-Mar-95                                  |
|                                     |                                  | 0.9 $\pm$ 0.4    |           |           | U               |      | 0.4 16-May-95                                       |
|                                     |                                  | 0.8 J $\pm$ 0.3  |           |           | 1 J $\pm$ 0.3   |      | 0.3 31-Jul-95                                       |
| U-238                               | 0.79                             | 1.5 $\pm$ 0.4    |           |           | 1.5 $\pm$ 0.6   |      | 0.4, 0.6 25-Oct-95                                  |
|                                     |                                  | U                |           |           |                 |      | 12-Apr-94   |
|                                     |                                  | 0.7 $\pm$ 0.3    |           |           | U               |      | 0.3 20-Mar-95                                       |
|                                     |                                  | U                |           |           | U               |      | 16-May-95   |
|                                     |                                  | 0.7 $\pm$ 0.3    |           |           | 0.4 $\pm$ 0.2   |      | 0.3, 0.2 31-Jul-95                                  |
|                                     |                                  | 1.9 $\pm$ 0.4    |           |           | 1.4 $\pm$ 0.5   |      | 0.4, 0.3 25-Oct-95                                  |

J Numerical value is an estimated quantity.  
U Undetected

**Table 4-6. SRPA background concentrations for contaminants of concern.**

| Compound                       | Knobel et al. 1991 | Knobel et al. 1992 |
|--------------------------------|--------------------|--------------------|
| bis(2-Ethylhexyl)phthalate     | 0                  | 0                  |
| Antimony                       | ND                 | ND                 |
| Arsenic (ug/L)                 | 2-3                | 2-3                |
| Cadmium (ug/L)                 | <1                 | <1                 |
| Nitrate (mg/L)                 | 0-1.4              | 1-2                |
| Tin                            | ND                 | ND                 |
| Am-241 (pCi/L)                 | not established    | 0                  |
| Np-237                         | ND                 | ND                 |
| Sr-90 (pCi/L)                  | 0                  | 0                  |
| U-234 (as total uranium, ug/L) | 0-9                | 0-3                |
| U-238 (as total uranium, ug/L) | 0-9                | 0-3                |

ND Not detected.

#### **4.4.1 bis(2-Ethylhexyl)phthalate**

The organic compound bis(2-Ethylhexyl)phthalate, a known laboratory contaminant and carcinogen, was detected at a maximum concentration of 370 ug/L, which significantly exceeds the 1E-6 risk-based tap water concentration (RBC) of 4.8 ug/L. Table 3-21 indicates the compound was also detected in surface water of the IWP, though the blank associated with the surface water sample also indicated bis(2-Ethylhexyl)phthalate contamination.

As can be seen in Table 4-3, bis(2-Ethylhexyl)phthalate exceeds the RBC of 4.8 ug/L in almost every sample (nine of ten samples with detectable quantities). Samples collected in May, 1995 from wells M-12 and M-13 are flagged with the data qualifier "B" indicating the contaminant was also detected in associated blank samples; however, information regarding the blank sample analysis was not included in the analysis presented here. Though Table 4.4 contains ten data points, no obvious trend in concentration over time is discernible. It can be seen from the table that the upgradient concentrations in well M-12 are consistently higher than the concentrations from the downgradient well M-13. Note that there is no known background concentration or MCL for bis(2-Ethylhexyl)phthalate.

#### **4.4.2 Antimony**

Antimony exceeds the corresponding RBC of 14.6 ug/L in wells with detected concentrations. Antimony was detected in wells M-12 and M-13 from samples collected in March and October of 1995, respectively. The M-12 sample is flagged with the "B" qualifier indicating antimony contamination of

the associated blank; however, details of the associated blank are not included in this analysis. Antimony was detected in both the IWP surface water and the sludge at the bottom of the EBR-II Leach Pit. The maximum detected concentration (105 ug/L) is much higher than the associated MCL (6 ug/L); therefore, further analysis in the BRA is recommended.

#### **4.4.3 Arsenic**

Arsenic is an ubiquitous element of the upper lithosphere and averages about 5 g/ton in igneous rocks (Knobel et al. 1992). Concentrations of arsenic in 74 Snake River Plain (SRP) aquifer samples collected in 1989 ranged from 1–5 g/L, with a mean of 2.5 ug/L, and median of 2 ug/L. Concentrations from 37 samples collected in 1988 ranged from 1–21 ug/L, with a mean of 3.1 ug/L and a median of 2 ug/L. This suggests the background groundwater concentration of arsenic is about 2–3 ug/L.

Arsenic is reported to have both carcinogenic and non-carcinogenic toxic effects. The screening level concentration based on a hazard quotient of 0.1 is 1.1 ug/L which is notably higher than the 1E-06 risk-based screening concentration of 0.05 ug/L; yet, all nine samples with detectable concentrations of arsenic exceed even the higher 1.1 ug/L criterion. These samples were collected between May, 1994 and October, 1995 from all of the wells listed in Table 4-2. Four of the nine samples are flagged with “B” qualifiers indicating similar contamination was detected in an associated blank. The details of a blank collected on October 25, 1995 show a concentration of 91.5 ug/L, considerably higher than the 1.9 and 3.6 ug/L detected in two wells sampled on the same day; however, both the blank and the M-13 sample have an “N” data qualifier associated with them indicating a spiked sample recovery was not within control limits.

No trends, either spatial or temporal, can be discerned from the available arsenic data; it appears to be randomly scattered. A MCL has been established at 50 ug/L for arsenic. The maximum detected concentration (3.8 ug/L) is more than an order of magnitude less than this MCL.

#### **4.4.4 Cadmium**

Estimates of cadmium abundance in crustal material are as large as 0.5 ppm (Knobel et al., 1992). In igneous rocks, the average abundance is about 0.13 ppm. Samples collected in 1989 from the SRP aquifer indicate concentrations ranged as high as 3 ug/L, though most samples showed < 1 ug/L.

The MCL for cadmium has been established at 5 ug/L. Groundwater samples collected in the vicinity of ANL-W indicate that cadmium exceeds this MCL but only slightly (6.2 ug/L). Cadmium is a noncarcinogenic contaminant that is screened in this analysis using a screening criterion (1.8 ug/L) which is based on a hazard index of 0.1; the two samples containing detected concentrations of cadmium, collected from wells M-12 and M-11 in April of 1994, exceed the 1.8 ug/L screening criterion. Cadmium was detected in both the IWP surface water and the sludge at the bottom of the EBR-II Leach Pit. There is no discernible trend other than the upgradient well M-12 shows higher concentrations than the downgradient M-11 well. Additional samples will be collected in accordance with the ANL-W Groundwater Monitoring Plan to see if this trend continues.

#### **4.4.5 Nitrate**

Nitrate concentrations in groundwater are most commonly from anthropogenic sources, including chemical fertilizers, barnyard wastes, and septic tank drainage. In aquifers that contain dissolved oxygen, such as the SRP aquifer, the stable form of dissolved nitrogen is the nitrate ion. Nitrate concentrations as nitrogen in 92 water samples collected from the SRP aquifer ranged from 0–4.7 mg/L (0–4,700 ug/L),

with a mean of 1.3 mg/L (1,300 ug/L) and a median of 0.98 mg/L (980 ug/L). Other samples collected in 1989 indicate nitrate concentrations (as nitrogen dissolved in water) range from about 1-2 mg/L (1,000-2,000 ug/L) (Knobel et al., 1992).

Nitrates pose a noncarcinogenic toxic hazard to human health. The screening criterion of 5,800 ug/L is based on a hazard quotient of 0.1. As such, six out of ten samples with detected concentrations exceed the criterion. None would exceed a criterion based on a hazard quotient of 1.0. Note that nitrate was also detected in the IWP surface water. The MCL for nitrates is set at 10 mg/L (10,000 ug/L). The maximum detected concentration from ANL-W wells, however, is less than this; therefore, nitrates should probably be eliminated from further analysis in the BRA.

#### 4.4.6 Tin

No MCL has been established for tin. Similar to nitrates, tin was screened using a criterion based on a hazard quotient of 0.1; as a result, the one sample containing detectable tin, collected from well M-13, fails this criterion though it would have screened out if the criterion was based on a hazard quotient of 1.0. Analysis of the contaminant was not performed in any other wells, the IWP surface water, or in the removed Leach Pit sludge.

#### 4.4.7 Am-241

For radionuclide contaminants in general, uncertainties (counting error) that are at least one-half the reported value indicate less than 95% confidence in the positive result (RUST 1994). The set of 13 radionuclides detected in ANL-W groundwater samples consists of five isotopes which fail the RBC screening step. These contaminants (Am-241, Np-237, Sr-90, U-234, and U-238) were also detected in the sludge removed from the bottom of the EBR-II Leach Pit. Though the uranium and transuranic isotopes listed here were not analyzed for in the IWP surface water, gross alpha measurements were made and indicate the possible presence of the isotopes (see Table 3-21).

Gross analyses involve the measurement of total radioactivity as either alpha or beta particle radiation given off during the decay process. Generally, laboratories report the analytical results referenced to one particular alpha- or beta-particle emitter. Gross alpha-particle concentrations in groundwater are given as the total of both suspended and dissolved fractions and are reported in micrograms per liter as natural uranium. Samples collected from the aquifer in 1989 ranged from  $0.38 \pm 0.14$  to  $17.1 \pm 1.1$  ug/L, with a mean of  $3.14 \pm 0.27$  ug/L and median of  $2.645 \pm 0.22$  ug/L. For the Snake River Plain aquifer, this range is about 0-3 ug/L (Knobel et al. 1992).

Transuranic elements may be produced in nature because of the availability of neutrons that can be captured by uranium isotopes (Knobel et al. 1992). In uranium minerals, the ratio of detectable Pu-239 to U-238 is about  $1E-12$ . Total uranium concentrations in basaltic rocks, such as those that constitute the SRP aquifer, are relatively small (about 1.2 ppm). Given this low abundance and the low ratio of transuranics to uranium, it is fair to assume the background concentration of transuranic elements in groundwater from the SRP aquifer should be near zero. SRP aquifer samples collected in 1989 ranged from  $-0.04 \pm 0.05$  to  $0.21 \pm 0.08$  pCi/L, with a mean of  $0.045 \pm 0.032$  pCi/L and a median of  $0.02 \pm 0.03$  pCi/L, indicating the background concentration of this isotope in the Snake River Plain aquifer is essentially zero.

Three samples collected from wells M-12 and M-13 contained detected concentrations of Am-241 that exceed the associated RBC of 0.15 pCi/L. These range from 0.2-0.53 pCi/L. These were collected from the M-12 and M-13 wells in July of 1995. The 0.53 pCi/L was detected in upgradient well M-12.



The third sample is an estimated value. A fourth sample contained detected Am-241 concentration of 0.15 pCi/L, equal to the RBC.

The MCL has been established for Am-241 at 6.34 pCi/L; this is more than an order of magnitude greater than that detected in well M-12. The Am-241 data are plotted in Appendix J. No real trends are discernible though M-12 concentration is greater than M-13 concentration and both seem to increase with time; however, this is based on very limited data. A plot of gross alpha measurements in several ANL-W wells over time is included in Appendix J. This plot also indicates no real discernible trends.

Am-241 is not likely to be mis-identified. If Am-241 is truly present in the groundwater, then the presence of Pu-239, Pu-238 and enriched uranium would be easily detected. Although U-234 and U-238 were detected, the detected concentrations fall easily within the range of naturally occurring uranium in groundwater. Although other isotopes have similar alpha emission energies (i.e., Rn-222 has an alpha emission energy of 5.4895 MeV compared to Am-241 alpha energy of 5.4857 MeV) it is unlikely a noble gas such as radon would remain in the sample following the required preparation. The lack of plutonium detection and the lack of any source for well M-12 to be contaminated by indicates the two detections of Am-241 in well M-12 and the two detections in well M-13 are actually the result of problems with analytical quality control. Such problems are currently not uncommon (personal communication, D. Sill, RESL, 1996).

#### 4.4.8 Np-237

There is no known MCL for Np-237. The RBC screening criterion is 0.22 pCi/L. The maximum detected concentration is 7.1 pCi/L. One sample, collected from well M-13 in July of 1995, returned a concentration of  $0 \pm 0.1$  pCi/L. All of the six remaining samples, collected from wells M-12 and M-13 in 1995, exceed the RBC. No real trend is discernible, though concentrations of Np-237 measured in M-13 appear to decrease with time; also, concentrations in samples from M-12 appear somewhat higher than in M-13.

Two samples (one from M-12 in July, 1995 and the other from M-13 also in July) have uncertainties greater than half the reported value; indicating less than 95% confidence in these two values.

A sample collected from the monitoring well immediately downgradient of the Leach Pit (well M-11) was collected in May, 1991 shortly after the well was completed. A positive detection of  $0.4 \pm 0.2$  pCi/L was determined from this sample. This value is greater than the RBC of 0.22 pCi/L and is lower than any of concentrations detected in the 1995 sampling campaign.

Np-237 does not occur naturally in groundwater. It may contaminate groundwater as a result of anthropogenic sources but none is known that might explain the detection of Np-237 in the M-12 well. Additionally, Np-237 will not be detected by alpha spectroscopy without detecting Am-241 at much higher concentrations. Due to the relative half-lives of Am-241 (432 years) and Np-237 ( $2.14 \times 10^6$  years), the abundance of Am-241 in a groundwater sample would be approximately ten thousand to a million times more than the abundance of Np-237. This is not what is indicated in the ANL-W groundwater samples. The groundwater samples collected March 20, 1995 indicate the detected concentration of Am-237 ( $0.53 \pm 0.1$  pCi/L in well M-12) is actually less than the detected concentration of Np-237 ( $7.1 \pm 0.6$  pCi/L in well M-12). It is also possible to misidentify U-234 as Np-237 since these two have similar alpha emission energy ranges. Again, quality control at the analyzing laboratory is suspect (personal communication, D. Sill, RESL, 1996).

#### 4.4.9 Sr-90

Strontium-90 does not occur naturally with the exception of natural reactors such as Oklo in Gabon, Africa, where nuclear fission reactions have occurred in a uranium-enriched deposit. This radionuclide, however, is anthropogenically present in groundwater as a fission product of nuclear weapons testing (Knobel et al., 1992). Dissolved concentrations of Sr-90 in water samples collected from the SRP aquifer in 1989 ranged from  $-0.51 \pm 0.041$  to  $2.93 \pm 0.20$  pCi/L, with a mean of about  $0.099 \pm 0.048$  pCi/L and median of  $0.083 \pm 0.065$  pCi/L. All of these statistics are below the method detection limit for the method used in 1989 to analyze these samples. As a result, the best conclusion is to assume that the background concentration of Sr-90 in the Snake River Plain aquifer is zero (Knobel et al. 1992).

Table 4-3 shows the results of four groundwater samples collected in 1995. The two low values of 0.1 and 0.7 pCi/L were collected from wells M-13 and M-12, respectively, on July 31, 1995. The two high values, 1,320 and 1,330 pCi/L, were collected from M-12 and M-13 on October 25, 1995. These greatly exceed the RBC for this isotope (0.85 pCi/L). It should be noted that these two higher results are flagged with the "J" qualifier indicating that the associated numerical value is an estimated quantity. Note that Sr-90 was detected in the IWP surface water (see Table 3-21).

The sudden jump in value from July to October indicates either the arrival of a significant Sr-90 plume or that there is an error in either the reported July or October sample values. An incorrect value may be the result of problems in sample collection, handling, transport, analysis, or even the entering of data into the ERIS database. Since the data are Level A validated data, it is unlikely an error in entering the data in ERIS.

No trend is discernible based on the limited data (four points); however, Sr-90 is a beta emitter and, as such, a plot of gross beta measurements taken of samples from various wells at ANL-W is included in Appendix J. This plot confirms the general lack of a trend, spatially or temporally, and shows the suspiciously high data values from October, 1995.

#### 4.4.10 U-234 and U-238

Three naturally occurring isotopes of uranium are U-238, U-235, and U-234. Total uranium concentrations in SRP aquifer samples collected in 1989 ranged from about  $0.01 \pm 0.005$  to  $7.0 \pm 0.52$  ug/L, with a mean of  $3.35 \pm 0.18$  ug/L and a median of  $3.025 \pm 0.16$  ug/L. These indicate the background concentrations for total uranium in the SRP aquifer ranges from 0-3 ug/L (Knobel et al. 1992).

Three of the eight returned samples with detectable quantities of U-234 contained concentrations that exceeded the RBC screening criterion of 1.07 pCi/L. Two of these were from samples collected from well M-12; the other was collected from M-13. The MCLs for U-234 and U-238 are 14.5 and 14.6 pCi/L, respectively. U-234 and U-238 maximum detected concentrations are all about an order of magnitude less than their respective MCLs.

U-234 and U-238 were detected in a single groundwater sample (EBR11-MW-642) taken in May, 1991 from a depth of 642 ft in well M-11; however, the concentration for these isotopes was  $11.3 \pm 8.3$  pCi/L each. Though this 1991 concentration is greater than any detected in either well M-12 or M-13 for either U-234 or U-238 and is greater than the RBC used in this analysis, the uncertainty of the sample value is greater than one-half the measured value; therefore, there is less than 95% confidence in this value.

No real trends are discernible though, spatially, the upgradient well M-12 shows higher uranium concentrations than well M-13 and, temporally, they each appear to increase concentration with time; however, this is based on a total of five data points. The gross alpha plot of Appendix J also shows little trend.

## 4.5 References

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